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WATERSHED ECONOMIC EVALUATION SURVEY

(Review of Six BLM Watershed Activity Plans)

Final Report to

J.F. Sato and Associates
for
Bureau of Land Management
U.S. Department of the Interior
Denver Federal Center, Bldg. 50
P.O. Box 25047
Denver, CO 80225

by
Freeman M. Smith
and
David A. Harper, Richard G. Walsh, and James M. Kasal

Colorado State University
Fort Collins, CO 80523

September 15, 1987

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Executive summary

The Bureau of Land Management (BLM) has responsibilities for more than 155 million acres of public domain lands in western states. In addition to general management responsibilities, it is charged with maintaining the soil, water, and natural productivity of these lands for use by future generations of Americans. Under this mandate, the BLM has implemented a number of watershed improvement projects. Economic analysis of watershed improvement practices is an important component in the planning of such projects. The first part of this paper discusses the physical/biological effects of improvement practices and reviews the practices in six BLM watershed activity plans. Watershed improvement practices are grouped under structural, mechanical, chemical and managerial. The second part reviews the economic component of the six BLM watershed activity plans. A number of significant economic evaluation problems are discussed. These include: discounting and compounding errors, exclusion of relevant costs, inflation of benefits, failure to consider appropriate alternatives, various logic errors, and confusion of the "with-project and without-project" concept with the "before and after" concept. Recommendations with regard to the improved application of benefit/cost methodology include the establishment of a review board and use of a standardized framework for documenting the estimation of project outputs. In addition, some suggested alternatives for estimating nonmarket and market values are discussed.

Watershed economic evaluation survey (Review of six BLM watershed improvement projects)

Freeman Smith*
and
David A. Harpman, Richard G. Walsh, and James M. Kasal*

Introduction

The Bureau of Land Management is the largest single custodian of public land in the United States. The agency is responsible for more than 155 million acres of public domain lands in the 11 western states. These are primarily land that were not considered suitable for farming or for inclusion in national parks and forests. Because of the great diversity of these lands in terrain and climate, it is very difficult to characterize them. However, of primary concern, here are the vast rangeland areas used for grazing domestic livestock. Because of the steep rangeland terrain, soil erosion is a potential problem. Tolerable soil loss levels are low because of the thin soils and relatively slow rate of soil formation.

The Bureau is interested in improving the application of economics to the evaluation of watershed improvements. Evaluation of the benefits and costs of watershed projects is essential to carrying out the Bureau's mission of improving soil and water conditions on public lands. In recent years, considerable research has been undertaken to establish the cause-effect relationship between watershed improvement practices, the physical and biological outputs, and the economic benefits and costs.

The purpose of this report is to review six watershed improvement projects of the agency including: 1) the cause-effect relationships between practices (e.g., mechanical treatment, prescribed burns, gully plugs, herbicides, etc.) and physical-biological effects; 2) the strengths and weaknesses of

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* Professor Freeman Smith is with the Colorado State University, Fort Collins. Mr. Harpman is a graduate research assistant and Dr. Walsh is a professor in the Department of Agricultural and Resource Economics also with the Colorado State University. Dr. Kasal was formerly with USDA Economic Research Service. This study was funded by the Bureau of Land Management (Contract Nos. YA-558-CT6-0005 and YA-470-87-123) and, in part, by the Colorado Agricultural Experiment Station, Western Regional Project W-133, Benefits and Costs in Resource Planning. We are grateful for the helpful comments of Eric Janes, contract officer's representative, USDI Bureau of Land Management; and Tsegaye Hailu, J.F. Sato and Associates. The assistance of Chris Nelson is acknowledged. Errors and omissions are, of course, the sole responsibility of the authors.

procedures to estimate the economic benefits and costs of outputs; and 3) suggested methods to improve the economic evaluation methods.

The study plan divides the work into two parts. In Part A, Professor Freeman Smith describes the relationship between watershed improvement practices and the measurement of physical/biological effects. In Part B, David Harpman, Professor Walsh and Dr. Kasal evaluate the techniques used to estimate economic benefits and costs of the outputs of the watershed improvement practices on six watersheds. This is followed by a review of some economic evaluation techniques of both on-site and off-site outputs.

PART A

PART A

Watershed improvement practices for rangelands
Freeman M. Smith

A-I. The effects of grazing on hydrologic processes

Evaluating the effects of grazing on hydrologic processes has been a principal objective of watershed research over the last several decades. The effects of grazing are well- documented (Branson, Gifford, Renard and Hadley, 1981). Both necessarily and unfortunately, the interpretation of the research results are site-specific. Nevertheless, the following general conclusions hold:

(1) any grazing decreases final infiltration rates. After cessation of all grazing, recovery to pre-grazing rates may occur in a decade or not for several decades.

(2) Heavy grazing increases subsoil bulk density approximately 1.2 times the bulk density of ungrazed soils.

(3) The difference between the effect of light and moderate grazing on the final infiltration rate cannot be distinguished.

(4) On-site erosion increases directly with the percent of exposed bare soil. The threshold for accelerated erosion is bare soil exposure greater than 50%.

(5) Within and between habitat types, no good evidence supports a differential effect of different grazing systems on hydrologic processes.

The effect of range condition and grazing levels on infiltration was reviewed by Gifford and Hawkins (1978). From their synthesis of previous studies, it can be generalized that: taking the final infiltration rate on sites in excellent condition with light grazing as 100%; final infiltration rates in fair-to-good condition with moderate grazing is reduces 50% and final infiltration rates in poor condition with heavy grazing is reduced 75%. They also reported that the effect of light or moderate grazing was difficult to differentiate. While the many studies were site-specific, their synthesis established a nominal 4-fold variation in final infiltration rates at the extremes of range condition and grazing intensities.

Overland flow, or runoff, is the compliment of infiltration. The water that does not infiltrate is potentially available for runoff. However, excess rainfall at a higher position on a slope, may infiltrate at a lower slope position. Locally

decreased infiltration rates do not necessarily directly translate to a net increase in overland flow and surface erosion.

The effect of grazing on runoff and erosion is confounded by grazing history, the current grazing system, canopy and ground cover, soil properties, soil-surface conditions, soil water content, rainfall intensity, and rainfall duration. The results of plot and small watershed studies generally support a 2 to 3-fold increase in runoff with heavy grazing, compared to light or no grazing (Branson, et. al., 1981). This generalization must be used with caution if one extrapolates from plots and small watersheds to entire slopes and larger watersheds. The effect is closely related to the percent bare ground exposed under different grazing intensities. It is generally true that runoff is generated on sites with heavy grazing for rainfall intensities with lower rainfall recurrance intervals than on sites with light and moderate grazing (Hanson et. al., 1970). For storms with recurrance intervals for intensities or durations greater than about 10 to 15 years, runoff is independent of grazing intensities. Soil loss, erosion rates, and sediment yields under different grazing intensities are site-specific and are influenced by the interaction of slope overland flow, litter, exposed bare soil, surface soil erodibility, and geologic parent material. The only generalization that can be made on the effect of grazing intensity on soil erosion is that soil erosion varies directly with percent exposed mineral soil (Gifford, 1985).

Although grazing may have little impact on erosion if ground cover is maintained. Increased soil loss with grazing on some soils, can occur even with only slight increases in exposed soil and slight decreases in cover (Lusby, 1970).

A-II. Watershed improvement practices on rangelands

A watershed improvement practice is any natural resource management practice whose direct or indirect effect results in the protection, maintenance, improvement, mitigation, desired change, or restoration of watershed behavior. Watershed behavior is the acceptable hydrologic response of a watershed with respect to soil movement, surface and channel erosion, sediment yield, water yield, streamflow characteristics, and water quality.

Watershed improvement practices may be structural, mechanical, chemical, vegetative, or managerial. Managerial improvement practices include other resource management practices for other natural resources, such as the practices used for agriculture, range, forest, wildlife, fisheries, recreation, mining, and fire management. Any resource management practice that indirectly mitigates, maintains, or enhances a hydrologic process is considered to be a watershed improvement practice.

Structural watershed improvement practices are those practices that result in the construction of a structure to modify on-site or off-site hydrologic characteristics. The most obvious structural practices are the construction of check-dams, drop-structures, and reservoirs. Structural practices also include those that reshape the landscape: terraces, contour trenches, water-spreaders, water-harvesters, contour dikes, roads and trails, and snow-fences.

Mechanical watershed improvement practices are those practices that modify the soil surface to achieve a desired change in infiltration rates, infiltration opportunity, soil water recharge, and vegetative and litter cover. Through these direct changes, erosion rates and soil loss are also mitigated. Mechanical treatments are usually carried out with heavy equipment and various implements.

Mechanical improvement practices such as contour furrowing, chiseling, and pitting are practices that are intended to directly increase infiltration and to reduce runoff and erosion. Other mechanical practices such as chaining, plowing, root-plowing, scalping, imprinting, range fertilization, and seeding are primarily intended to increase forage production. Although these mechanical practices are usually considered to be range improvement practices, they could also be regarded as watershed improvement practices since they can indirectly result in desired modifications of infiltration, runoff, and erosion.

Chemical watershed improvement practices are few. Chemical range improvement practices, such as the use of herbicides to reduce plant competition or to promote a vegetation conversion which results in increased soil protection can also be considered watershed improvement practices. Chemical watershed improvement practices that are used to directy affect a hydrologic process include chemicals used in water-harvesting to seal the soil to achieve greater runoff. Other chemicals are those used to seal leaky reservoirs or used as anti-transpirants and evaporation suppressants.

Vegetative watershed improvement practices are those practices that use vegetative manipulation, usually to achieve an increase in water yield. Timber-harvesting, designed to increase water yield, is a vegetative watershed improvement practice. Vegetative conversion from brush to grass is also an improvement practice to increase water yield. In other cases, revegetation, afforestation, and reforestation are used as watershed improvement practices to restore acceptable levels of runoff, erosion, and sediment yield. Windbreaks are a different vegetative watershed improvement practice used to reduce wind erosion.

Managerial watershed improvement practices include all resource management strategies designed to sustain resource production. For example, a do-nothing watershed management strategy to maintain a sustained water yield of a given quality for a municipal water supply is a managerial watershed improvement practice. Another example is forest management for sustained timber yield. If the harvesting strategy and the harvesting methods include the integration of practices to mitigate slope failure, excessive runoff, and erosion, then the forest management practice is also considered to be a watershed improvement practice.

Grazing management and the associated improvement practices to optimize forage production, animal gains, and sustained production are managerial watershed improvement practices if they simultaneously achieve desireable effects on hydrologic processes. In a similar fashion, if a the fire management strategy indirectly accomplishes watershed management objectives, it can also be considered a managerial watershed improvement practice. Other resource management practices for agriculture, wildlife, recreation, and mining can also accomplish measures of soil and water conservation.

Appendix A-A is a list and brief description of watershed improvement practices. The list is not all-inclusive, but includes watershed improvement practices that have commonly been used on rangelands. The following section synthesizes the physical and biological effects that accompany different kinds of selected watershed improvement practices.

Appendix A-B reviews improvement practices as applied in six BLM watershed activity plans.

A-III. Physical/biological effects of watershed improvement practices

Recognizing that grazing affects the hydrologic processes, what watershed improvement practices can be employed to mititgate the undesireable effects or re-establish watershed stability if the effects of grazing have been severe? In the following section, the effects of the more common watershed improvement practices are presented. Table A-1 summarizes the CAUSE (watershed improvement practice); the EFFECTS (the expected results); and the BENEFITS (of the watershed improvement practices).

The Bureau of Land Management proposed a ranking of 5 current range improvement practices. The ranking was made considering both lessee and BLM preferences. The first is water-development; the second is fencing; the third is prescribed burning; the fourth is chemical treatment; and the fifth is mechanical treatment.

Evaluating the effects of water-development and fencing was beyond the scope of this contract. However, since water-development and fencing result in both animal concentration and more uniform animal distribution, respectively, of implementing both improvements would be a trade-off with respect to area-wide hydrologic effects. The effect of concentration at water-developments can be minimized through careful location and mitigative erosion practices. The effects of mechanical and chemical improvement and prescribed burning practices are discussed in more detail in this section.

Structural watershed improvement practices

Contour trenches. Contour trenches are designed to completely contain the runoff and sediment for a given design storm. Early studies (Bailey and Copeland, 1961; DeByle, 1970; and Doty, 1971) reported successful containment of summer runoff events in Utah and an increase in annual streamflow. DeByle concluded that the contour trenches on the eastern slope of the Sierra Nevadas reduced wet-mantle flood peaks. Doty noted that neither snowmelt runoff nor annual water yields were significantly changed by contour trenches on 15% of a 75-acre watershed near Farmington, Utah. The quantity of sediment intercepted was not reported for the studies although it is reasonable to assume that the trenches were effective in retaining the sediment produced on the slopes above them.

Contour trenches are expensive to construct. If they intercept runoff and sediment over a large area of a watershed (50%), one must assume that they would significantly reduce runoff volume, peakflow, and sediment for all runoff events equal to or less than the event for which they were designed. The disturbance caused during construction makes any net increase in forage doubtful. Although the sediment reduction benefit exists, their use is impractical except for severely eroded, highly critical watershed areas. Forage benefits are marginal, livestock movement is impeded, and the trenches permanently degrade the visual quality of the landscape.

Contour dikes and water-spreaders. Both contour dikes and water-spreaders are watershed improvement practices designed to retain or spread runoff to recharge soil water, promote increased forage production, and contain eroded soil and sediment. Contour dikes are constructed on gentle slopes to impound runoff. Water-spreaders, a system of contour dikes and a diversion dam on a near-by stream channel, are designed to divert and spread storm runoff. These improvement practices result in increased on-site local forage production and off-site control of runoff and erosion if properly sited, designed, constructed, and maintained.

Forage increases for properly designed water-spreaders varied between 10 and 20-fold (Miller, Branson, Shown, and Buller,1969). For their study no quantitative data was reported for sediment reduction, except that in some cases, excessive sedimentation had an adverse effect on forage yield. It is reasonable to suggest that the effective life of a single contour dike might be 15 to 20 years. The effective life a water-spreader system might be 50 to 100 years if the diversion dam and the contour dikes are adequately designed, constructed, and maintained.

Check-dams. Check-dams are small dams, constructed to engineering design, for stabilizing channel gradients, and reducing accelerated channel erosion, headcutting, and bedload transport. In some cases, salt yield may be mitigated. Check-dams are usually constructed in intermittent ephemeral channels, however, they are also used in perennial streams to improve fish habitat. Gully-plugs are undesigned small earth dams placed in channels to accomplish the same purpose. Without an engineering design, they are subject to failure.

The proper design of check-dams for channel stabilization requires a careful hydrologic analysis of the spectrum of recurrance intervals of peak flows, channel sediment storage, bedload transport, upland runoff, and erosion rates (Heede, 1966; Heede and Weatherred, 1981). Correctly designed and constructed check-dams stabilize channels, abate channel degradation, raise and widen channels, and reduce bedload transport rates.

Check-dams are rarely built singly. To attain channel or channel system stability requires that many check-dams be constructed on the entire channel network (Heede, 1977; Ruby, 1974). Earlier undesigned check-dams have failed (Peterson and Branson, 1962; Peterson and Hadley, 1960).

Although check-dams are purported to raise groundwater tables, the effect is usually confined to the area immediately behind the sediment-filled dam and the adjacent stream banks. Although it is conceivable that a system of check-dams might restore the entire alluvial aquifer, no studies of this kind have been reported. With natural revegetation or with planting, riparian habitats can be restored.

The life of check-dams for sediment storage varies from 15 to 30 years (King, 1966; Thomas, 1975), however, if virtual channel equilibrium is achieved, the effective life of the system of check-dams may be 50 to 100 years. No study has been reported concerning this aspect.

Check-dams are special-purpose watershed improvement practices, to be used only in critical erosion areas. On a strict economic basis, check-dams and gully plugs cannot be justified for channel stability and erosion control alone (Workman and Keith, 1975). If installed where riparian habitat and esthetic values are high, they may be beneficical.

Mechanical watershed improvement practices

Contour furrows, pitting, and ripping. All these mechanical treatments are designed to retain runoff and erosion on-site. The increased infiltration opportunity increases soil water storage, and subsequently, increases forage production. Eroded soil is retained behind the furrows or in the pits. In most studies, off-site reduction in erosion was not reported.

Branson, Miller, and McQueen (1966) carried out a comprehensive review of the effects of mechanical treatments on forage production and soil water storage. In terms of forage production, broadcast seeded-broadbase furrows (1.5 to 2 feet high) and contour furrows spaced 3 to 5 feet apart were the most effective, with 2 to 5-fold increases in forage production. Greatest responses occurred on mediun to fine textured soils.

At the time of construction the water holding capacity of the furrows, at 3 to 5 foot spacing was 2 inches (equal to the 2-hour, 50-year rainfall). Furrows spaced more than 5 feet apart are subject to breaching. The water holding capacity of the furrows was decreased by 60% within 5 years, and by 85 % by 9 years. Decreases in storage capacity beyond 9 years were slight. Similar observations were reported by Neff (1973) and Thomas (1975).

On the sites examined by Branson, Miller, and McQueen (1966), pitting and ripping showed little vegetation response. Barnes (1952); Rauzi (1956); and Rauzi, Lang, and Becker (1962) all reported that pitting in rangeland in Wyoming increased infiltration rates up to 5 years later. Information on erosion reduction were not reported. The effective life of pitting has been reported to vary from 3 years (Hickey and Dortignac (1964) to 10 years (Barnes, Anderson, and Heerwagen, 1958).

It is noteworthy that mechanical treatments have generally been more successful in the Great Plains and desert Southwest for vegetative response. Vegetative response to mechanical treatments has had limited success in the Intermountain Basin in Colorado and Utah (Branson, Miller, and McQueen, 1966; Gifford, 1975).

Chaining, plowing/reseeding. The mechanical treatments of chaining, plowing and reseeding are range improvement practices, and not watershed improvement practices per se. These practices

are intended to release desireable forage from competition or to improve forage production through subsequent seeding. A summary of hydrologic effects of these practices seems appropriate.

The effects of chaining on pinyon-juniper was reported by Gifford (1975). He concluded that infiltration rates, runoff, and erosion were affected marginally, if at all, by chaining. Only if debris was windrowed was runoff increased. Debris left-in-place was recommended.

Plowing decreases infiltration rates, but the degree of apparent decrease depends on soil texture. Net erosion and runoff were not different from the untreated sites. These results are anticipated, since plowing and reseeding are carried out on reasonably gentle, smooth areas.

Chemical watershed improvement practices

Chemical treatments. The principal chemical treatment for rangelands is herbicides. Numerous studies have reported 2 to 10-fold increases in forage production, increased animal weight gains, and increased carrying capacities (Valentine, 1980). The most common herbicides used for range improvement in the past have been 2,4-D, picloram, fenuron, and karbutylate. In western rangelands, herbicides have been used principally in the sagebrush-grass and pinyon-juniper types. The use of herbicides for controlling big sagebrush began in the early 1940's (Hyder, 1953). 2,4-D was the common herbicide used on rangelands. Environmental concerns and the promulgation of the National Environmental Policy Act resulted in curtailment of the once common use of herbicides on rangelands. Few registered herbicidal chemicals are available at present. Johnson (1987) and McDaniel and WhiteTrifaro (1987) discuss the more recent use of herbicides in pinyon-juniper control.

The physical effects of chemical improvement practices on infiltration, runoff, and erosion are beneficial . . . if the forage response is achieved. In terms of the effect of herbicides on turbidity and suspended sediment, if erosion is not increased, water quality criteria are usually met. However, since herbicides are attached to soil particles, and in some cases dissolved in runoff, chemical improvement practices can potentially have an effect on aquatic ecosystems.

Few studies have been designed and carried out to determine the effect of herbicides on infiltration, runoff, and erosion. What was studied was the effect of grazing, after the treatment. Where herbicides have been applied with minimal surface disturbance, i.e., aerial application, one would not expect any detrimental effect on hydrologic processes. But even without any increase in infiltration, one would expect the soil water

dynamics to be changed, since the evapotranspiration draft would be initially curtailed.

Eventual vegetation recovery of the previously-existing vegetation would eventually re-establish the original pattern of soil water distribution and withdrawal. If the herbicide treatment achieved a successful conversion to a vegetation type with a different root distribution, then the hydrologic behavior of the treated area would be changed. If the rooting characteristics of the 2 vegetation types are the same or if the soil depth is less than about 3 feet, hydrologic changes are undetectable.

The effect of herbicides on infiltration is beneficial. Dead leaf-fall, additional litter, and increased canopy cover and litter production promote infiltration opportunity, which reduces overland flow and erosion. Pechanec, Plummer, Robertson, and Hull (1965) reported that erosion was not a hazard on sprayed sagebrush.

The effect of herbicides on soil water content and its distribution depends on the precipitation zone, soil properties, effective soil depth, and root distribution of the vegetation. On arid sites in Wyoming, changes in soil water were not detectable (Fisser, 1968). In the Red Desert in Wyoming, Alley (1965) measured higher soil water content on the sprayed areas, but there was no difference 3 years later. Sturges (1977) reported a net increase of total soil water after spraying sagebrush in south central Wyoming. The estimated increase was not significant after 10 years. On a sandy-loam soil with a permeable sandy-loam C horizon, he found that the net increase in soil water content occurred below 3 feet. Soil water withdrawal above 3 feet on the sprayed plots, exceeded withdrawal on the unsprayed plots, due to the increased grass production.

Chemical treatment of entire watersheds has increased subsurface flow and base flow. Hibbert, Davis, and Scholl (1974) reported an initial 3-fold increase in water yield in Arizona chaparral after chemical treatment. Lewis (1968) and Clary (1975) detected increased water yields after herbicide treatments on oak woodland in California and pinyon-juniper in Arizona, respectively. Ranchers' have observed the rejuvenation of springs and the extension of the duration of intermittent streamflow after entire watersheds have received chemical treatment (Alley, 1965).

Burning. Prescribed burning is an effective tool to achieve vegetation changes through reduction in plant competition and through re-initiation of natural succession. Reseeding after burning can redirect and accelerate vegetational changes.

Unfortunately, there is a great paucity of research findings on the effects of prescribed fires on infiltration, runoff, and erosion. There is a plethora of information on the effects of wild fires (USDA, 1978a; USDA, 1978b), most of which pertains to forests, not rangelands.

Soil physical properties are not changed significantly, except when high-intensity fires have occurred. Infiltration rates are generally reduced, but the degree of reduction varies with fire intensity (USDA, 1978a). If litter and surface organic horizons are not completely burned, decreased infiltration rates are not detectable. Well-documented studies of fire-induced water repellancy have been reported by DeBano (1968).

Little is documented on the effect of prescribed fires on streamflow and erosion on rangelands. What little is known has been done on chaparral types in Arizona and California. Rowe, Countryman, and Storey (1954) present the following conclusions for California chaparral: peak flows increase 4 to 5-fold immediately following a fire. Recovery to pre-fire conditions occurs within between 15 to 30 years. Erosion increases relative to the degree of burn-effect. For a 20% burn-effect, erosion increases 7-fold the first year and recovers to pre-fire levels within 5 to 10 years.

Following wildfires, annual sediment transport increases from 1 to 5 orders of magnitude have been reported (Glendening, Pace, and Ingebo, 1961; Krammes. 1960; and Hibbert, Davis, and Scholl, 1974). Wright, Churchill, and Stevens (1976) reported an increase of 2 orders of magnitude in sediment transported after a prescribed burn in Texas.

The effect of fires on nutrients on rangelands is poorly documented. Following a wildfire in Arizona chaparral, Longstreth and Patten (1975) reported an order of magnitude increase in nitrate-N (NO_3-N) concentration in streamflow. They also reported a nominal 20% decrease in cation concentration after the same fire. In contrast, after a prescribed fire in southern California, DeBano and Conrad (1978) found that total nitrogen loss by sediment transport was 2 orders of magnitude greater than for pre-fire conditions. Solution loss of cations was 2 orders of magnitude and sediment transport loss of cations was 3 orders of magnitude greater.

There are too few studies of the effects of prescribed fires to offer a meaningful summary. Blaisdell (1953) found the soil water content of the upper layer was diminished, by intense fires, but unaffected by light and moderate fires. Others found the soil water decreased (Anderson, Smith, and Owensby, 1970); and increased (Sharrow and Wright, 1977) on burned sites. Successful prescribed burning of sagebrush in Idaho resulted in

70% increase in carrying capacity without reseeding (Pechanec, Stewart, and Blaisdell, 1954). After 15 years, the carrying capacity was still 60% greater than unburned sagebrush. With reseeding, carrying capacity was increased 5 to 12-fold.

Hibbert et. al. (1974) reported a notable increase in water yield after burning. Summer flows were prolonged, and in some cases, once intermittent flow became continuous. The benefits of increased water yield are obvious for livestock and wildlife. Carefully prescribed fires on hydrologically appropriate sites warrant very high priority.

Managerial watershed improvement practices

Grazing systems. In addition to structural, mechanical, and chemical watershed improvement practices, grazing systems are managerial practices to optimize forage production, animal weight gains and sustained resource productivity. A grazing- system is a management strategy which applies a schedule of recurring periods of grazing and deferment among different management units (pastures). To the extent that a grazing system maintains or enhances infiltration, it is a watershed improvement practice.

Heady (1984) considers a grazing system as a management practice designed to take advantage of periods when plants are tolerant (or intolerant) to grazing, to achieve better range condition, greater forage production, greater stability, and high resiliency of the range resource. Recognizing this multiple objective, he considers a grazing system as a selected combination of grazing and non-grazing. Grazing periods are: (1) season-long; (2) late grazing (phenologically); 3) early grazing; and (4) short-term grazing. Non-grazing periods are: (1) season-long; (2) late; (3) early; (4) short-term no grazing; and (5) no grazing. The usual grazing system terminology of rest, defer, continuous, rotation, high intensitylow frequency, etc. are combinations of the terms he proposed.

Blackburn (1984) addressed the question of whether or not grazing intensity and specialized grazing systems differentially affected hydrologic process within and between habitat types. He analized available data for 12 habitat types. He concluded that there was virtually no good evidence that grazing practices or grazing systems differentially affected hydrologic processes within habitat types. His conclusions suggest that while different grazing practices do affect hydrologic processes on a given site, the differences are smaller than the variation within and between habitat types. Recognizing such great variability, Jameson (1986) recommended adaptive management systems, in place of fixed grazing systems.

Blackburn's conclusions are not unexpected. Smith (1986) emphasized that the variability of the interactions of grazing, soils, topography, and the spectrum of climatic variability make the meaningful synthesis of results of range hydrology research doubtful. Hutchings and Stewart (1953) and others have repeatedly pointed out that the variation of forage response to precipitation is far greater than the variation of forage response to grazing.

In summary, any grazing decreases final infiltration rates. Increases in runoff and erosion may or may not be evident, depending on site characteristics, grazing history, grazing intensity, and the recurrance intervals for storm intensity and duration. Thus, the effect of grazing is site-specific and cannot be extrapolated without due caution.

Table A-1. Illustrative CAUSE-EFFECTS-BENEFITS
(assuming complete success)

CAUSE: Contour Trenches on Critical Areas

EFFECTS:

Physical Effects

Interception of slope runoff
Retention of sediments
Reduction of flood peaks
(possible) Increased subsurface water yield

Biological Effects

Minor to none

BENEFITS:

Reduced off-site sediment delivery (25-50 years)
Reduced off-site facility maintenance and repair costs (roads, culverts, bridges) (25-50 years)

(possible) Reduced flood peaks (decreasing, 25 years)
Improved water quality (decreasing, 25 years)

DISBENEFITS:

Degraded visual quality (permanent)
Impeded grazing animal movement (permanent)

CAUSE: Contour Dikes and Water-Spreaders

EFFECTS:

Physical Effects

Detention of overland flow or diverted runoff
Retention of sediments
Increased soil water content
Reduction of peak flow

Biological Effects

Increased forage production
Improved non-game, small animal habitat

BENEFITS:

Reduced off-site sediment delivery (50-100 years)
Increased AUM's (100 years)
Reduced peak overland flow (15-25 years)
Non-game habitat (100 years)

CAUSE: System of Check-dams

EFFECTS:

Physical Effects

Reduced off-site sediment delivery
Reduced off-site salt delivery
Increased channel stability

On-site increase in water stored in impounded sediments and adjacent stream banks

(possible) Recharge of alluvial aquifer
Extended ephemeral or intermittant low flow

Biological Effects

Locally increased vegetation production
Locally enhanced riparian habitat

BENEFITS:

Reduced off-site sediment delivery (100 years)
Reduced down-stream facility maintenance (100 years)
Reduced down-stream salt yield (100 years)
Increased AUM's (100 years)
Increased visual quality (100 years)

CAUSE: Contour Furrowing

EFFECTS:

Physical Effects

Increased infiltration opportunity
Decreased off-site sediment delivery
Locally increased soil water storage
Decreased off-site runoff

Biological Effects

On-site increased forage production
On-site increased ecological diversity

BENEFITS:

Increased AUM's (10-50 years)
Reduced off-site sediment delivey (decreasing, 10 years)
Increased off-site water quality (decreasing, 10 years)

CAUSE: Chaining, Plowing/Reseeding

EFFECTS:

Physical Effects

On-site surface disturbance
On-site decreased infiltration
(possible) Increased runoff
(possible) Off-site sediment delivery
Increased soil bulk density

Biological Effects

Increased forage production
Increased habitat diversity
(possible) Increased game and non-game wildlife
Increased firewood

BENEFITS:

Increased AUM's (decreasing, 25 years)
Increased wildlife values (decreasing, 25 years)
Firewood availability increased (25 years)
Decreased fire hazard (? years)

DISBENEFITS:

Degraded visual quality (? years)

CAUSE: Prescribed Burning

EFFECTS:

Physical Effects (initial)

(possible) Increased water yields
(possible) Increased erosion and sediment yield
Increased soil water storage
(possible) Increased peak flows
Increased cation, total nitrogen loss
(possible) Prolonged low flow

Biological Effects (temporary)

Partial or complete loss of vegetation
Partial or complete loss of habitat
Minor wildlife loss

Biological Effects (long term)

Increased vegetation production
Enhanced habitat diversity
Increased game and non-game wildlife
(possible) Enhanced riparian habitat

BENEFITS:

Increased visual diversity (25 years, after 10th year)
(possible) Increased water yield (decreasing, 25 years)
Increased AUM's (decreasing, 25 years)
Increased wildlife values (25 years)
Decreased fire hazard (? years)

DISBENEFITS:

(possible) Increased erosion and sediment yield
(temporary) Loss of habitat (10 years)
(temporary) Loss of forage (1 year)
(temporary) Degraded visual quality (? years)

CAUSE: Herbicide Treatment

EFFECTS:

Physical Effects

Increased soil water storage
Change in soil water redistribution
(possible) Increased subsurface flow water yield
(possible) Rejuvenation of springs
(possible) Extended ephemeral or intermittent flow
(possible) Mass-wasting

Biological Effects

Loss of forage (1 year)
Loss of wildlife habitat (1 year)
Increased forage production
Increased habitat diversity

BENEFITS:

Increased AUM's (decreasing, 25 years)
(possible) Enhanced riparian habitat (25 years)
(possible) Livestock/wildlife water supply (25 years)
(possible) Improved livestock access (5-25 years)
(possible) Increased habitat diversity (25 years)

DISBENEFITS:

(possible) Nutrient losses (1-2 years)
Increased fire hazard (? years)
(possible) Degraded water quality (? years)
Loss of wildlife habitat (? years)
Degraded visual quality (? years)

Appendix A-A

Watershed and Range Improvement Practices

Burning

Prescribed burning is a management tool to remove unwanted components of the vegetation to favor more desireable species, to induce more vigorous regrowth, or to effect a conversion of one vegetation type to another. Prescribed burning is a strategically planned practice where meteorlogic conditions and fuel loading are considered for achieving the desired fire intensity.

Cabling

Cabling is a mechanical treatment to remove undesireable shrubs and small trees on rangelands. A heavy (2-inch diameter) cable is drug between 2 caterpillars in a U- or J-shape. The purpose is to remove or thin undesireable brush and trees. For most applications, chaining is preferred to cabling, because the cable tends to slide over the smaller bushes and trees.

Chaining

Chaining is a mechanical treatment to eliminate unwanted shrub and tree components of the vegetation, i.e., pinyon, juniper, sagebrush. Chaining is accomplished by attaching an anchor-chain to 2 caterpillars and dragging the chain over the ground surface in a U- or J-shape.

Check-dams (gully-plugs)

Check-dams are small engineered dams usually constructed in head-cutting gullies to restore channel-system stability. Mechanical watershed improvement practices, in conjunction with the installation of check-dams, must be applied the the contributing watershed. Gully-plugs are undesigned small earth dams placed in channels to accomplish the same purpose, but without an engineering design, they are subject to failure.

Chemical treatment (plants)

The use of herbicides to remove undesireable or competing vegetation is a chemical treatment practice. The herbicide may be selective or non-selective and applied from the ground of aerially.

Chiseling (or ripping)

Chiseling is a mechanical treatment to break up and overturn compacted soil layers that inhibit infiltration and root

development. The chisel attachment is pulled along the contour behind a caterpillar.

Contour dikes

Contour dikes are built to retain and spread runoff on slopes. They are small versions of water-spreaders, but do not involve the diversion of streamflow.

Contour furrows

Contour furrowing is a mechanical treatment to create parallel furrows on the contours of the topography. The furrows are usually 10 to 15 inches deep, with small transverse dams in the furrows. Spacing between contour furrows varies as a function of slope and anticipated runoff volume.

Contour trenches

Contour trenching is a mechanical treatment to create very large trenches on the contours of the topography. The trenches can be as deep as 4 feet and as wide as 12 feet. The purpose of contour trenches is to completely store overland flow and sediment.

Dams

Small dams may be constructed to retain water for livestock use and to realize better cattle distribution or they may be constructed to reduce flood peaks and sediment yield.

Fencing

Fencing is an improvement practice to exclude livestock from riparian areas or springs; to partition off pastures for use in a grazing system; or to achieve desired grazing distribution on open ranges (drift fence).

Fertilization

Fertilization is the application of standard agricultural fertilizers on pastures and meadows to increase forage production.

Grazing systems

Grazing systems are strategies to simultaneously optimize forage production and animal weight gains on a sustained basis. Different grazing systems, such as continuous, seasonal, high intensity/low frequency, rotation, rest, deferred, etc., and their combinations are developed with consideration of the growth characteristics and phenology of the forage and browse species.

Gully plugs (see check-dams)

Guzzlers (see water-harvesting)

Herbicides (see chemicals)

Imprinting

Imprinting is a mechanical soil treatment where a large heavy cylinder with a geometric pattern of projections is pulled behind a tractor or caterpillar. As the cylinder rolls on the soil surface, the projections "imprint" small depressions. Runoff accumulates in the small depressions, providing infiltration opportunity.

Interseeding (Scalping)

Interseeding is a method of introducing desired forage species in an existing stand where the soil or slope conditions present an erosion hazard. A scalper pulled behind a tractor or caterpillar removes a narrow strip of the vegetation. The resulting furrow is seeded with the desired species.

Pitting

Pitting is a mechanical treatment through which small plugs of soil are removed, creating small holes or depressions. The purpose of pitting is to promote forage production through retention of a larger portion of the overland flow on-site to enhance infiltration, thus reducing runoff and soil loss.

Plowing

Plowing is a mechanical treatment to eliminate unwanted vegetation, i.e., sagebrush, or to prepare a site for seeding. A variety of plows have been designed specially for rangelands.

Railing

Railing involves dragging a railroad rail, I-beam, or channel iron across the ground with a tractor or caterpillar to uproot and break off small shrubs such as sagebrush or cactus.

Revegetation

Revegetation is the establishment of plants in highly susceptible or severely eroded areas. The practice varies from broadcast or aerial seeding after fires, to reseeding perennial grasses and forbs, or planting browse and tree seedlings.

Reservoirs (see dams)

Roads (trails)

Roads and cattle trails are not strictly watershed improvements, however they are included here because their improper design or maintenance can lead to severe erosion.

Root plowing

Root plowing is a practice to sever the roots of undesireable shrubs and small trees at depths that range from 6 inches to 18 inches, depending on the rooting characteristics of the brush or trees. Since root plowing also destroys all the herbaceous vegetation, it is usually followed by seedbed preparation and reseeding.

Seeding

Seeding is the practice of planting seeds in rangelands. It can be done through typical agricultural methods or through aerial broadcasting.

Snow-fencing

Snow-fencing is the practice of designing and constructing snow-fences to promote the accumulation of snow and soil water recharge. The practice is limited in rangelands, but has been used to promote successful revegetation on mined lands.

Stock tanks (see dams)

Terracing

The construction of terraces is usually associated with agriculture on steep slopes. However, they are used as a watershed treatement practice on critical areas to reduce runoff and sedimentation. Level terraces are designed to impound and hold water in arid areas. Graded terraces, much like contour trenches, are designed to intercept and divert runoff at velocities that do not erode the soil.

Vegetation conversion

Vegetation conversion is the ultimate objective of various improvement practices. Such practices as burning, herbicide application, chaining, etc., are intended to convert vegetation types such as brush or trees to desireable grass, forbs, or shrubs.

Water-harvesting

Water-harvesting is a method of developing a water supply for livestock by treating the soil of a small natural or man-made microwatershed to increase runoff. The runoff is collected and stored and distributed to a trough. A variety of soil treatments are used to increase runoff: removal of vegetation; compaction; applying salt, wax, or asphalt emulsions; paving; or covering with butyl rubber membranes. Water-harvesters constructed for wildlife have been given the name of "guzzlers". Water-harvesters are also called catchment basins or trick-tanks.

Water-spreaders

Water-spreading is a technique to divert and retain ephemeral or intermittent steamflow on a gentle slope adjacent to the stream or wash through a system of dikes. The purpose of the practice is to essentially irrigate gentle slopes for increased forage production.

Windbreakers

Windbreak are tree plantings to reduce wind velocities. While usually associated with agricultural fields or farm buildings, windbreaks are used to stabilize soils where wind is the dominant erosive force.

Appendix A-B

Review of six BLM watershed activity plans

Willow Creek, Lewiston District, Montana

U.S. Dept. of the Interior. 1985. Willow Creek Interdisciplinary Watershed Activity Plan Environmental Assessment. Bureau of Land Management, Lewiston, Montana.

Watershed improvement practices

The principal objectives for the Willow Creek Project were flood control, sediment yield reduction, and erosion control. The watershed improvement practices selected to meet these objectives for the Willow Creek Project were all structural controls.

These structural controls included the construction of detention dams, retention dams, diversion dams, water spreading dikes, and drop-structures. The control structures for the Willow Creek Project were designed for a 25-year life for sediment storage.

Evaluation of the effects of the watershed improvement practices

The original design studies for the control structures were not included in the Willow Creek Environmental Assessment. However, it is important to recognize that during the design-life of the structures (25 years) the objectives for flood control and sediment yield reduction were attained.

Simulation model analysis demonstrated a reduction of 79% of flood peak discharge of the 100-year storm. A re-analysis of an actual flood (July 1962) confirmed that the control structures reduced the flood peak discharge 45%. Sediment yield has been reduced 55%.

Erosion control was perhaps stated loosely as an objective. Obviously, on-site surface erosion was not controlled, since the control structures have intercepted the sediment delivered from their watersheds. Apparently, the effects of grazing practices, designed to increase forage production and litter and reduce exposed bare ground, were not documented.

Discussion

The purpose of the Willow Creek Environmental Assessment was to compare alternatives for future action. In 1985, without any action, the reservoirs will still allow for the storage of sediment for approximately 20 years. No analysis was presented

for this estimate. Further analysis should be carried out to determine the effect of channel storage (as the dams eventually breach and begin to release their stored sediment) on the "apparent" sediment yield reduction at the outlet of the watershed.

It would be expected that the apparent sediment yield reduction would continue a few decades beyond the 20 years estimated. However, the aggrading of the channel over time and readjustment of the channel might also lead to a loss of riparian habitat.

Pinyon Watershed, Cedar District, Utah

Tucker, Ronald, 1985. Bureau of Land Management, U.S. Dept of the Interior, Report No. EA UT-040-85-87. Cedar City, Utah.

Watershed improvement practices

Head-cutting gullies and channel entrenchment have led to a lowering of the alluvial water table and consequent loss of riparian habitat in the Pinyon Watershed. The activity plan proposes to stabilize the head-cutting gullies and restore the riparian habitat through strategic fencing to protect water sources and riparian areas; construction of check-dams with revegetation; spraying and reseeding; and mechanical treatment and reseeding.

Construction of the system of check-dams with revegetation are clearly "watershed improvement practices", however, fencing, herbicide and mechanical treatment, and reseeding are also considered watershed improvement practices, cum range improvement practices.

Evaluation of the effects of the watershed improvement practices

Systems of properly designed and constructed check-dams can stabilize head-cutting gullies and (supposedly) promote the recovery of water tables of alluvial aquifers. However, the entire gully and stream network must be included in the system of check-dams.

In addition, the head-cuts themselves must be re-sloped and protected from grazing until vegetation has become established. Furthermore, in some cases, diversion of runoff above the head-cuts must be accomplished. Mention was not given to these additional requirements.

Herbicide and mechanical treatment, followed by reseeding has shown limited success in re-establishing increased ground

cover in the particular location under discussion. On gentle slopes, the net on-site effects of mechanical treatment, in terms of increased runoff and soil movement, are usually small. The principal value of the reseeding would be increased forage production, rather that reduced soil loss.

Discussion

Several considerations arise in terms of valuing the benefits of systems of check-dams in stabilizing channels depends on the rate that sediment is supplied to the channels and the rate that the channel sediment is stored behind the check-dams, complete stabilization may require many decades. Thus, benefits accrue very slowly.

Second, since the check-dams must be built, maintained, and repaired continuously, a major item in the budget is the cost of maintenance and repair. This is virtually always omitted in the economic analysis.

Finally, the most important design requirements for check-dams are (1) the design flood discharge and the design of the spillway, and (2) the design of the down-stream apron and bank protection. With limited rainfall intensity data in the remote areas that BLM manages, questionable confidence can be placed in determining correct "design storms" or "design floods".

The trade-off between uncertainty (spillway capacity) and repair becomes a dilemma. In the longterm activity plan under consideration, attention should be directed to analyzing the trade-off between spillway capacity costs and the cost of maintenance and repair.

Bear Creek, Prineville District, Oregon

Century Testing Laboratories, Inc. 1980. The Bear Creek Watershed Project. Report to the Bureau of Land Management, U.S. Dept. of the Interior, Bend, Oregon.

Watershed improvement practices

This report to BLM evaluates the results of the rehabilitative and management practices carried out on the Bear Creek Project. The objectives of the Bear Creek Project were to reduce erosion, flood, and sediment damage. The principal watershed improvement practices on the 7 different allotments were: juniper thinnings, seeding, fencing, spring development, and the construction of sediment basin.

Evaluation of the effects of watershed improvement practices

No details were given for the methodologies for any of the watershed improvement practices. However, "good" results were reported (without quantitative data) for vegetation response after juniper thinning and drilled seeding. In the summary and conclusions, sediment basins were observed to be filled with sediment . . . and therefore were considered to be effective in reducing sediment yield.

Stream fencing was considered to be beneficial in mitigating bank disturbance and bank erosion (incorrectly called "channel stability" in the summary). Riprapping was accomplished by using the trunks of the felled junipers. Sediment was observed to occur in the rip-rap. It is not known whether the riprapping was designed or random.

Discussion

The Bear Creek Project and the consultant's report may reflect the more common outcome of BLM watershed improvement activities. The details of the project, the design and methodologies for the watershed improvement practices, and the evaluation of the effect are not available in sufficient detail to properly critique.

Lower Wolf Creek, Craig District, Colorado

U.S. Dept of the Interior, 1985. Lower Wolf Creek Environmental Assessment. Bureau of Land Management, Craig, Colorado.

Watershed improvement practices

Three structural control watershed improvement practices are proposed to address the problems of head-cutting gullies, high sediment yields, and high salt yields on 2 allotments in the Lower Wolf Creek watershed.

The proposed structural controls are: retention pits for salt-bearing sediments; earth gully-plugs (check-dams) to stabilize head-cutting gullies; and hypalon drop-structures to extend the life of existing reservoirs.

Evaluation of the effects of the watershed improvement practices

The purpose of the retention pits is to contain all runoff and sediment. The design-life of the pits is 10 years. When the pits are full, it is proposed to either clean them out or construct an outlet and allow the flow to be discharged across the slope or diverted. No details are provided for these plans.

The eventual maintenance cost is not included in the economic analysis.

The small earthen gully-plugs are proposed to be built above the retention pits and the existing reservoirs on which the drop-structures will be built. although the anticipated "life" of the gully-plugs is 5 years, it is proposed that the gully plugs will be constructed without a design, uncompacted, and shaped with a bulldozer. It is stated that over-topping flow will run around the edges of the small structures.

The hypalon drop-structures are innovative. There is no reason to expect that they will work well if properly designed. The expected life of the hypalon drop-structures is 25 years. What is the remaining useful life of the reservoirs that they projects?

Discussion

Several questions arise when examining Table 1. For example, for projects 1174 and 1047 (drop-structures), does the 2 acre-feet of storage represent the remaining useful storage in the existing structures?

Also, although the footnote states that the useful life of the projects if 10 years (based on an erosion rate of 5 to 7 tons/acre/year). Using 5 tons/acre/year for 10 years for project 1174 results in a life of only 5 years. Using the same rate for project 1047 results in a life of only 3 years. Likewise, the same calculations for the pits show that the usable storage will be filled in approximately 5 years. (It is possible that an important explanation is missing in the report.)

Another technical point that is troublesome is the statement that the gully-plugs will not have any designed spillway. In addition, the cost of $4.00 per gully-plug seems entirely too low, considering that bulldozer work costs at least $20.00 per hours. Consideration should be given to more specific spillway design and cost estimates.

A final comment is in order regarding the physical/chemical effectiveness of the proposed method for salinity control. The basic question is - what is the eventual fate of the salts that are removed from the channel system? Do the salts remain in the solid storage or do they dissolve and re-enter the hydrologic system? In the latter case, the salinity "problem" has been moved from the channel system to the soil water and (perhaps) the groundwater systems. Admittedly, to analyze the methodology would have to be site-specific.

Elephant Skin Wash, Montrose District, Colorado

U.S. Dept. of the Interior. 1984. Elephant Skin Wash Salinity Control Project. Bureau of Land Management, Montrose, Colorado.

Watershed improvement practices

The salinity control project proposes to apply the watershed improvement practices of diversion dams and ponding dikes (water-spreaders), primarily to reduce sediment yield and salt yield. Anticipated ancillary benefits of the impounded water are reduction of flood peaks, the creation of local seasonal water supply for sheep and wildlife, and increased forage production from the water-spreading. Note that an addendum substantially modified the original project.

Evaluation of the effects of the watershed improvement practices

The designs for the diversion dams and ponding dikes are appropriate. But consideration should be given to spillway designs for both the dams and the dikes to assure that rip-rap is not required to prevent breaching.

No mention is made as to whether or not soil piping is a potential problem.

Discussion

The diversion dams and the ponding dikes are designed for the 2-year 24-hour storm, using the Soil Conservation Service Curve-Number procedures. This procedure is acceptable when no site data exist. However, the thunderstorm events, the runoff volume and the peak discharge calculated with this method must be regarded with caution. The tendency is to under-design structures.

No provision is made for the maintenance costs over the life of the project.

Long Gulch, Montrose District, Colorado

U.S. Dept. of the Interior, 1985. Long Gulch Sediment Control and Riparian Habitat Improvement Plan. Bureau of Land Management. Gunnison, Colorado

Watershed improvement practices

The watershed improvement practices proposed for the Long Gulch plan are the construction of porous check-dams, and head-cut reshaping. The purpose of the treatments is to arrest head-cutting gullies, reduce sediment yield, promote channel

stabilization, and enhance alluvial aquifer recharge. Benefits that are expected to accompany the structural control treatment are: decreased peak flows, increased vegetation production, extended seasonal water supply for livestock and wildlife, and improved wildlife habitat.

Evaluation of the effects of the watershed improvement practices

The proposed construction of 27 check-dams (only for Site 1) and the re-shaping of the active head-cuts will arrest the incipient gulling if properly designed, installed, and maintained.

The check-dams are designed for a 5-year life, before they are filled. The check-dams will continue to act to reduce the channel gradient. With revegetation channel should assume a stable equilibrium.

Discussion

The hydrologic calculations and the description of the methodology for site-selection and construction are clear. Calculations for the spillway designs are nominally based on the 2 to 5-year recurrence interval peak flow. With a change in the spillway design, a more conservative 10-year flood could be accommodated.

On page 16, some confusion begins . . . it is stated that the spillway capacities would be able to accommodate the 25-year flood. However, after discussing risk analysis, the designed spillway capacities revert to the 5-year flood event and the 25-year spillway capacity becomes the "safe flood capacity".

No provisions are made to accommodate an emergency spillway, except the verbiage "... this can be accomplished by designing each structure and the surrounding area to dissipate the flood flow energy as much as possible ..." No further details are provided.

Part of the treatment is to construct channels through the existing alluvial deposits of several tributaries. Without seeing the site, it is impractical to object to constructing the channels. However, leaving the alluvial material in place may promote more rapid channel stabilization in the gully above.

Again, no costs have been included in the maintenance and repair of the structures.

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PART B

PART B

Watershed economic evaluation:
David Harpman, Richard B. Walsh, and James M. Kasal

B-I. Review of six BLM watershed activity plans

In this section, we summarize the problems identified in each of six watershed improvement studies, in particular, the quantification of physical outputs and types of economic analysis employed including direct costs, direct benefits, and regional economic impacts. Also included are suggested techniques to improve comparison of the benefits and costs of watershed projects. Comments on each of the six watershed studies are included in appendices B-A to B-F.

Physical outputs

One factor which impedes the valuation of many range improvement projects is the lack of output data. It seems apparent from our survey of the literature that there are very few studies which purport to link a particular conservation practice with a quantifiable output. For instance, not a single study which we reviewed linked a given practice to the (measured) quantity of top soil saved. To further compound the valuation problem, if it was assumed that a given quantity of soil was retained on site, there were no tenable linkages offered to relate this quantity to increased forage production. Hence, there was no empirically justifiable link to an increase in carrying capacity (AUM's) on the range. The state of the art in economics is such that the vast majority of physical outputs can be valued. And, in fact, increased forage production can be valued both in terms of livestock production, and, as is demonstrated in this report, in terms of wildlife production. However, the lack of quantifiable outputs precludes the assignment of value in the vast majority of studies which were reviewed. For this reason we recommend that the BLM devote the time and money necessary to establish the physical linkages which are required to quantify the outputs of small range improvement projects. We believe that this course of action will facilitate the economic valuation of the benefits of these projects.

Based on the review of the six documents provided by the BLM, it appears that a common fault is the failure to identify and quantify the outputs of the proposed project. In the majority of cases, the levels of physical outputs were either asserted or assumed and no documentation of the methodology employed is contained in the analysis. While it is recognized that some assumptions are necessary in any analysis: without documentation, many of the assumptions made in the studies reviewed appear to have little logical foundation and little

reference to a parallel situation. Further, given current agency practice there is little or no accountability for the product estimates developed. This may encourage overly optimistic assumptions about project benefits. The development of SAGERAM (see Appendix B-G for a description) is a partial solution to some of these problems. The use of this analysis package insures that the prices used to value selected costs and benefits will be constant within a given region. In addition, errors in applying discounting techniques are minimized. Unfortunately, no program can guard against unreasonable or incorrect entry of the physical project outputs. Documentation requirements for the assumptions made and the methodologies employed to estimate the physical and economic impacts are minimal or non-existent. Therefore, it is recommended that the BLM adopt some type of agency wide framework to guide and document the identification and quantification of the physical and economic project effects.

The real value of requiring a standard input methodology, such as this, is to establish a consistent and repeatable analytic framework where the methodology employed is explicitly stated. Such a framework would lend itself to careful review and accountability. A highly simplified version of such a framework is presented in Table B-1.

Benefit/cost methodology

The six documents reviewed do not follow accepted benefit/cost procedure. Five problems are particularly noteworthy. First, none of the analyses presented costs and benefits for alternatives beyond the recommended alternative. Thus, there was no economic justification presented for choosing among the alternatives. Second, in 3 out of 6 applicable cases no alternative projects are apparent. The decision maker is confronted with a choice of either constructing the project as recommended, or, opting for the "do nothing" alternative. Third, where alternatives are presented in the text, they are uniformly construction oriented. Logical alternatives such as improved grazing management and reductions in livestock use are not explored. Thus, the alternative set is biased initially. Fourth, in each of the documents reviewed, the concept of "with project and without project" is incorrectly confused with "before and after". The benefit of a project is the difference between the benefits which would have accrued to the project site without the project and the benefits estimated to accrue with the project. Without project benefits may increase, decrease, or remain static over time. In Figure B-1 this corresponds to situations A, C, and B, respectively. The line P represents the estimated benefits; associated with a hypothetical project.

In all of the documents examined, it was implicitly assumed that the without project benefits would remain static over time corresponding to situation B). This is what is referred to as "Before and After" analysis and is flawed to the extent that conditions on the project site do not remain constant. For

example, several of the documents reviewed alluded to the expected deterioration of range conditions in the absence of project construction. This would correspond to situation C. The correct measure of project benefits, at each point in time, is then the difference between P and C. Thus, the incorrect use of "Before and After" (B) instead of "With and without" (C) resulted in a substantial understatement of project benefits. Conversely, had range conditions been expected to improve over time, all else being equal, the incorrect use of "Before and After" (B) instead of "With and Without" (A) would have resulted in a gross overstatement of project benefits. Hence, confusion of these two concepts can have serious analytical consequences.

Table B-1. Identification and Quantification of Project Outputs

Physical Output[1]	Estimation Methodology[2]	Physical Quantity Estimated	Time Component[3]	Individual Responsible
sediment				
salinity				
wildlife				
fisheries				
recreation				
forage				
water, yield, quantity, timing				
minerals				
other impacts				

[1] All physical outputs, which are expected to occur due to project implementation, either gains or losses, should be identified whether quantified or not.

[2] The methodology used should be documented in detail, references should be cited, and parallel situations described as appropriate.

[3] The time of output occurrence in relation to the project lifespan should be explicitly stated. Time trends should be estimated and the methodology noted.

[4] The name, title, and contact address of the individual responsible for deriving these estimates should be listed. The doctrine of personal accountability should be stressed.

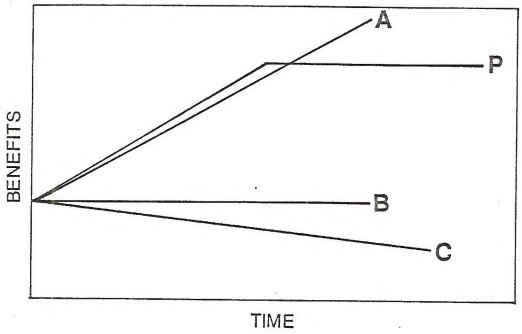

Figure 1. With and Without vs. Before and After

A = BENEFITS INCREASING WITHOUT PROJECT

B = BENEFITS REMAINING STATIC WITHOUT PROJECT

C = BENEFITS DECREASING WITHOUT PROJECT

P = ESTIMATED BENEFITS WITH PROJECT

Fifth, it is apparent that the basic techniques for discounting and compounding are incorrectly applied in several cases. Whether these instances are isolated computational errors or are deliberate could not be ascertained. In any event, the number of occurrences in the small sample of documents reviewed is substantial and points out the need for widespread corrective measures.

Owing to the poor quality of the analyses reviewed, two courses of action are recommended. They are (1) the establishment of a review and oversight board, and (2) initiation of short training courses in benefit/cost methodologies.

The purpose of a review and oversight board is to review documents for reasonableness and accuracy. Such a board, at least conceptually, would be empowered to require additional analyses and to approve or disapprove proposed projects. In its optimal configuration, the review board would be inter-disciplinary in nature. At a minimum, the following disciplines should be included: engineering, economics, and range science. Two additional benefits of such a board would be to reduce local bias in the decision-making process, and, to introduce personal accountability into these analyses.

Training of BLM field personnel in the benefit/cost technique is also of critical importance. Short courses in these techniques could be taught either by senior BLM employees or by outside personnel. Colorado State University, for example, currently offers, twice each calender year, a short course entitled "Agricultural Project Analysis with Micro-computer Applications". A course such as this could easily be tailored to fit the needs of BLM field personnel. It could then be presented in the field or at regional BLM offices as required.

Regional impacts

It was evident in all of the documents reviewed that very little time was devoted to the estimation of regional project impacts. It is certainly the case that regional economic impacts are not appropriate for inclusion in economic efficiency studies (Young and Gray, 1985). However, it is probably the case that few if any BLM projects, of the type examined, are economically efficient. This is the case since most of these projects are structural in nature. Hence, they require high capital outlays and produce largely localized benefits. On a regional economic basis, or possibly even on the basis of various social welfare concerns, more of these projects may be justifiable. Such projects may help to achieve desirable social goals such as alleviating unemployment and maintaining the family farm. These goals may, in part, be outside of the realm of national economic efficiency. Thus, the BLM may be doing a disservice to itself, and the users of the resources under its control, by ignoring the

aggregate implications of its small projects. It is recommended that future analyses maintain two accounts, one for national economic benefits and another for regional economic benefits.

B-II. Review of economic valuation techniques

The purpose of this section is to identify the outputs of watershed improvement practices and to review some of the more important contributions to the growing body of literature on the economic evaluation of outputs. While the list of range improvement practices followed by the BLM is quite extensive, the list of measurable physical outputs resulting from these practices is short. They typically include changes in the following:

(1) forage
(2) sedimentation
(3) salinity
(4) wildlife and fish populations
(5) water quality, yield, and timing
(6) recreation use

In the absence of superior knowledge[1], the use of the U.S. Forest Service RPA values is recommended for outputs 1, 2, 5, and 6. There are three overriding reasons for making this recommendation. The values used will be consistent within a given region. The small size of many BLM projects precludes more accurate (and expensive) estimation methodologies. BLM field personnel are not trained in the application of complex estimation techniques. The recommended values for these outputs are presented in Table B-2. It is expected that updated estimates of these values will be available from the Forest Service in late 1987.

The following subsections contain recommended economic valuation techniques for both offsite and onsite outputs, in particular, the value of forage for livestock and wildlife production, the fishery, salinity, instream flow, and erosion resulting from wind and water.

Offsite impacts

Most analyses of soil erosion focus on onsite problems such as diminished agricultural productivity that occur when erosion takes place. In addition to these onsite problems, there are problems caused by the sediment and other contaminants after they

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[1] Knowledge of more accurate or more applicable values. For example: erosion from adjacent BLM land causes sedimentation in an irrigation structure. The appropriate value of soil retention, in this case, is the avoided cost of dredging.

Table B-2 NFS Benefit Values - 1985 Program
by Resource Activity and Region [1982 $]

[Regions] Recreation Activity	[1] Northern	[2] Rocky Mountain	[3] South western	[4] Inter mountain	[5] Southwest	[6] Pacific Northwest	[8] Pacific Southern	[9] Eastern
[$/RVD]*								
Motorized Boating-Standard	8	8	10	7	6	4	8	12
Less-than-standard	3	4	5	4	3	2	3	6
Nonmotorized Boating-standard	11	10	12	15	9	6	5	9
Less-than-standard	6	5	6	8	5	3	3	5
Motorized Travel-standard	7	8	7	6	8	8	7	9
Less-than-standard	4	4	4	3	4	4	4	5
Camping-standard	5	6	9	5	8	6	10	11
Less-than-standard	3	3	5	3	4	3	5	6
Picnicking-standard	4	9	9	5	5	6	6	8
Less-than-standard	2	5	5	3	3	3	3	4
Hiking-standard	8	9	10	9	11	10	13	18
Less-than-standard	4	5	5	5	6	5	7	10
Wilderness-standard	12	12	14	12	14	18	16	18
Less-than-standard	6	6	7	6	7	10	8	10
Downhill-skiing-standard	30	34	31	34	35	31	29	35
Less-than-standard	16	18	16	18	18	16	15	19
Water Sports-standard	8	8	9	8	9	8	9	11
Less-than-standard	3	4	5	4	5	4	5	6

* Standard - RVD's reflect maintained, high quality recreation opportunities.
Less than standard - RVD's reflect lower quality recreation opportunities resulting from less intensive management.

Table B-2 [con't] NFS Benefit Values - 1985 Program
by Resource Activity and Region [1982 $]

[Regions] Activity	[1] Northern	[2] Rocky Mountain	[3] South western	[4] Inter mountain	[5] Pacific Southwest	[6] Pacific Northwest	[8] Southern	[9] Eastern
Fish & Wildlife								
[$/MFUD]								
Big Game Use	31	41	30	31	30	30	25	38
Nongame Use	25	25	25	25	25	25	25	25
Anadromous Fish Use	23	NA	NA	23	31	33	NA	38
Resident Fish Use	11	11	13	11	12	15	13	13
Other Game Use	21	19	18	19	18	19	18	21
WL/F REC Use Standard	20	21	19	18	18	21	18	20
WL/REC Use Less Than Standard	13	14	13	12	12	14	12	13
[$/M Lbs.]								
Anadromous Fish Comm. Harvest	1050	-	-	1050	1840	1050	-	-
[$/M Pelts]								
Furbearer Harvest	15300	25800	45650	20720	21840	24880	13730	21710
Range								
[$/AUM]								
Grazing Capacity-Obligated	11.15	10.50	8.74	11.00	10.40	10.50	6.10	6.00
[$/Animal]								
Wild Horses & Burros	200.	200.	200.	200.	200.	200.	200.	200.
Water								
[$/Acre Foot]								
Increased Water Yield	13.50	45.50	43.50	12.00	59.00	—	—	—
[$/M Tons]								
Sediment Reduction	7.00	6.00	5.00	6.00	10.00	6.00	4.00	4.00
[$/Acre Foot]								
Improved Water Quality	2.71	4.84	3.80	2.72	3.44	1.40	11.57	16.78
Maintained Water Quality	0.39	0.69	0.56	0.39	0.49	0.20	1.65	2.26

leave the eroding fields. Between the time these pollutants leave the field and the time they are carried out to sea or come to rest in a reservoir or some other location, they can cause a wide variety of in-stream and off-stream damages which are defined as offsite impacts. Not all of the impacts are strictly the result of soil erosion. Some are caused by dissolved pollutants that storms might carry off the land even if little or no erosion occurred (i.e., salt). However, because erosion usually is a critical element in the process, it is difficult to distinguish these impacts from those caused by erosion itself.

Recent studies indicate the magnitude of these offsite impacts (Clark et al., 1985; Clark, 1985). This work divides offsite impacts into in-stream damages of $4.1 billion (Table 3) and off-stream damages of $1.9 billion (Table 4). Tables B-3 and B-4 indicate the order of magnitude on a national scale of the offsite damages associated with sediment. They are only gross estimates of the problem. However, when the economic impact of project proposals are made, serious consideration should be given to these off-site impacts. Only a few studies have estimated user willingness to pay for erosion control and no studies have estimated nonuser willingness to pay. Measurement of these values would facilitate estimation of socially optimum levels of soil erosion control and would also provide new understanding of the relationship between use and preservation-related perceptions of benefits. We recommend that the BLM undertake research on the measurement of these two basic types of benefits from watershed protection programs.

In-stream impacts are caused by sediment, nutrients, and other erosion related contaminants in streams and lakes. They impact aquatic organisms, water based recreation, water storage facilities, and navigation. Aquatic organisms are affected by sediment and its associated pollutants. Spawning areas, food sources, and habitat can be destroyed. Nutrients, pesticides, and other contaminants can be toxic to fish. Recreation is impacted by erosion through the reduction in fish populations, turbidity, and reduced water quality. Water storage facilities incur damages because of reduced storage capacity, additional sediment dredging costs, additional wear on electrical generating equipment, and changes in evaporation from water bodies as well as increased lake cleanup. Navigation is impacted through increased costs for channel maintenance. Other in-stream impacts are associated with lowered property values and preservation values as well as the impact on commercial fisheries.

Off-stream impacts are associated with flooding, water conveyance, water treatment, and irrigation. Flooding problems are increased by sediment through aggradation of streambeds, larger water volumes, and larger cleanup costs. Water conveyance

Table 8-3. Examples of In-stream damages from soil erosion [in millions of 1980 dollars]

Type of Damage	Range of Estimates	Single-Value Estimate	Cropland Share
Biological Impacts		no estimate	
Recreational damages			
Freshwater fishing	160– 870	450	180
Marine fishing	330– 1,800	450	180
Boating	390– 1,200	680	270
Swimming	70– 1,200	450	180
Waterfowl hunting	0– 200	50	20
Accidents – fatal	0– 100	–	–
nonfatal	0– 100	–	–
Subtotal [rounded]	950– 5,600	2,100	830
Damages of water-storage facilities			
Construction of sediment pools	220– 620	350	110
Dredging and excavating	20– 100	50	15
Replacement capacity	60– 450	250	80
Reduced evaporation*	–10– 200	–100	–30
Increased evapotranspiration	5– 100	50	15
Lake cleanup	17– 85	40	15
Subtotal [rounded]	310– 1,200	640	200
Costs of navigation impacts			
Delays to commercial shipping		no estimate	
Accidents	20– 100	40	13
Damage to engines		no estimate	
Dredging	400– 700	520	170
Dredge spoil disposal		no estimate	
Subtotal [rounded]	420– 800	560	180
Other instream damages			
Commercial fisheries	260– 410	300	120
Property values [aesthetics]		no estimate	
Preservation values	160– 2,400	530	210
Subtotal [rounded]	420– 2,800	830	330
Total instream damages [rounded]	2,100–10,000	4,100	1,500

*Reduced evaporation is a benefit of suspended sediment and, therefore, is included as a negative number.

Source: Clark, 1986

Table B-4. Examples of off-stream damages from soil erosion (in millions of 1980 dollars).

Type of Damage	Range of Estimates	Single-Value Estimate	Cropland Share
Sediment-related flood damages			
Increased flood heights from channel aggradation	0- 250	50	16
Increased flood volumes	10- 50	23	8
Direct sediment damages			
Urban	270- 540	350	110
Other	175 350	250	82
Loss of life	14- 30	-	-
Reduced agricultural productivity	0- 170	100	33
Subtotal [rounded]	490- 1,400	770	250
Water conveyance facilities			
Drainage ditches			
Flood damages		no estimate	
Sediment removal	90- 185	120	50
Pumping water			
Increased pumping costs	less than one million dollars		
Equipment maintenance costs		no estimate	
Irrigation canals			
Sediment removal	30- 70	50	25
Weed control	15- 50	35	25
Subtotal [rounded]	140- 300	200	100
Water treatment for municipal and industrial use	50- 500	100	30
Other off-stream effects			
Municipal and industrial users	500- 1,200	900	300
Stream electric power plants			
Maintenance of cooling systems	23- 69	45	15
Increased efficiency*	-100- 400	-150	-50
Irrigation			
Sealing soil surface		no estimate	
Salinity	4- 35	25	15
Value of nutrients*	-15- 37	-25	-8
Subtotal [rounded]	410- 870	800	280
Total off-stream damages [rounded]	1,100- 3,100	1,900	660

*Reduced evaporation is a benefit of suspended sediment and, therefore, is included as a negative number.

Source: Clark 1985

facilities are damaged by sediment as it settles out in drainage and irrigation ditches. This leads to increased costs of maintenance. Water treatment costs for municipal and industrial user increases because sediment removal systems need to be expanded or cleaned more frequently. Irrigation is impacted by additional sediment because of reduced infiltration caused by fine salt. In addition, sediment and the accompanying dissolved salts can lower crop yields. Especially in parts of the western U.S., salt accumulations can become a very serious problem leading to the abandonment of irrigated acres.

The methodology of estimating the economic costs of environmental damages still is relatively crude. If reliable estimates of the physical damage are available and if the items have a clear market value, damage estimates are fairly straightforward. Unfortunately, this is usually not the case. In most cases, the extent and value of the damages are unknown. Typically, the damages are difficult to measure and depend on the specific water body affected and the particular uses that are made of it. Many of the uses involve activities that normally take place without market exchanges. Therefore, there is considerable work that needs to be done by both economists and the physical scientists to improve the methodology of handling these estimates.

Several excellent papers on the economic evaluation are presented in Chapter 4 and 5 of National Research Council (1984). These papers present economic estimates of the returns from various range improvement practices such as spraying, burning, chaining and seeding. Other papers discuss economic evaluation methods and techniques such as benefit-cost analysis, linear programming, input-output analysis, etc. In particular, methodologies for the evaluation of nonmarket outputs are presented. The strengths and weaknesses of these methods and techniques are presented. In addition, several of the papers include lists of recommendations for improving economic evaluation of public projects by BLM and other federal agencies.

A recent study estimated both on-and-off-farm impacts for the Rock Creek, Idaho, Rural Clean Water Project (Kasal et al., 1987). This study estimates installation costs and changes in production costs for a variety of erosion control practices on irrigated land. Both short-term and long-term yield impacts are estimated. Estimates of off-site impacts include an examination of recreation fishing, sediment removal from ditches, canals and drains, power generation, water treatment, property values, and wildlife habitat.

Practices generally associated with watershed projects are directed at controlling erosion or improving water infiltration. The onsite impacts of uncontrolled erosion are reflected in decreased productivity. Decreases in irrigated cropland

productivity were estimated to range from 1/8 to 1/2 of one percent per year in the Rock Creek, Idaho Rural Clean Water Project (Kasal et al., 1987). Risser (1981) estimates yield declines the cornbelt as much as 0.6 percent.

The lowest levels of erosion in the U.S. have been observed in the west where sediment loss from undisturbed forests is usually less than 0.36 mt/ha. A nine-year study of Idaho rangeland indicates mean sediment yields ranging from 0.31 to 1.66 mt/ha. (Froehlich, 1976).

Contour furrowing on rangeland is a generally accepted practices to increase water infiltration. Branson (1966) shows yield increases of 118 percent in forage production. Wight et al., 1978, indicate a yield increase of 165 percent due to contour furrowing of rangeland.

Forage for livestock

Comparison of the RPA grazing value for Region 2, the Rocky Mountains, with the results of several Colorado studies is useful. McKean et al. (1986) applied the contingent valuation method to estimate a logit demand function for federal grazing allotments in Colorado. Adjusting for below-average ranchland values, perhaps due to land quality or other factors, the authors report a value of $6.66 per AUM. This figure compares quite closely with alternative estimates. Gee (1982) estimated the value of the marginal product for federal grazing to be approximately $7.90 per AUM. Similarly, Bartlett et al. (1981) found the value of the marginal product of forage in Colorado to be $7.14 per AUM, assuming a variable herd size, and $8.21 per AUM, assuming a fixed herd size. These studies assumed average livestock prices for their time periods. Prices and price expectations have diminished since those studies were undertaken. More recent appraisals by the USDA Forest Service and USDI Bureau of Land Management (1986) indicate a price of $5.31/head/month in northwest Colorado and $6.84/head/month in Southwest and Central Colorado.

Forage for wildlife

Efficiency in production is achieved when an input, such as forage, is allocated in such a manner that its marginal value product (MVP) is equal in all uses. This principle is imbedded in linear programming models such as FORPLAN, a model currently used to aid planning decisions by the U.S. Forest Service. The marginal value product of forage in livestock production has been estimated in a number of contexts and is often used in benefit/cost analyses and in allocation models. However, unless the MVP's of forage in wildlife production are similarly estimated, they are not available for use in these kinds of analyses. A paper by Loomis (1985) illustrates a methodology

for estimating the value of an AUM of forage in the production of elk and deer. This methodology is actually applied to BLM administered land in Idaho. In this study a regional travel cost model is used to estimate the marginal value of an additional elk, deer, etc. From the demand equations, the second-stage, or hunt specific demand curves are derived. This results in a demand curve for added travel distance and number of visits demanded. Travel distance is then converted to travel cost using the average reported transportation cost and travel time valued at one-third of the average wage rate.

Hunting areas 36 and 36B, located near Challis, Idaho on BLM administered land, were then selected to illustrate the use of this technique. Based on information provided by area game managers, it was determined that a 25 percent increase in elk harvest in unit 36 would require a harvest of 28 additional elk. This, in turn, would require an increase in the herd base of 378 animals with a herd composition of 19 percent bulls, 54 percent cows, and 19 percent calves.

With respect to the second-stage demand curve, a 25 percent increase in elk harvest would shift the elk hunting demand curve for this unit rightward. The area between the new demand curve and the old demand curve was then found to be $14,075 annually. The marginal value of an additional elk is then: $14,075/28 = $502.

Assuming that an adult elk requires .54 AUM's and a juvenile elk .27 AUM's, the following relationships hold:

1 bull elk harvested requires a 13.5 animal base herd
1 Elk Harvested (EH) = 6.3058 AUMS * 12 months
1 EH/year = 75.6696 AUMS/elk/year

Therefore, the following production function can be constructed:

EH = .01322 AUMS

Finding the marginal product of this relationship

$$\frac{EH}{AUMS} = .01322$$

Then, multiplying it by the marginal value of an elk ($502) yields:

($502) * (.01322) = $6.65 per AUM

which is the MVP of an AUM of forage used to produce elk on this site. This value can be incorporated into linear programming models, such as FORPLAN, and used as a basis for the optimal allocation of forage between livestock and wildlife. The technique illustrated by Loomis, while simplistic, is widely

applicable. This technique could be used by the BLM in valuing the increased forage produced by small range improvement projects.

In a related study of wildlife production in wetlands, Matulich and Hanson (1986) modeled the supply response to watershed protection programs.

Fishery

Project impacts on recreational fisheries can be valued in terms of increases or decreases in the number of fish caught and the average size of the fish caught. Probably the best examples of this are contained in works by Loomis (1986, 1987). In practice, a travel cost model, either site specific or regional, is first estimated and then a second stage demand curve is derived. This allows the net economic value of the fishery to be estimated. Next, changes in either the average catch or the average size of the fish caught are estimated. These changes are then introduced into the travel cost model causing a shift in site demand. The difference in the net value between the without-project and the with-project condition is calculated. This value is the net economic impact of the project.

Useful guide to the travel cost model are the publications by Rosenthal, Loomis, and Peterson (1984) and Ward and Loomis (1986). An excellent desk top computer program is available for estimating travel cost models and net willingness-to-pay (Rosenthal, et al., 1986).

Few studies have measured the effect of the number and size of fish caught on the value of fishing. In the past, Harris (1983) reported the data were not sufficient to estimate the effect of number of fish caught on the benefits of fishing in Colorado. More recently, a contingent valuation study by Johnson and Walsh (1987) of 200 fishermen at Blue Mesa Reservoir, Colorado, indicates that the value of catching additional fish is 0.95, and larger fish $1.25 per inch. This is somewhat lower than reported by Sorg, et al. (1985) based on a telephone survey of resident and nonresident fishermen in Idaho. They reported catching an average of 3.3 fish per day. The authors reported an incremental value of $1.20 per each additional fish per day. Also, benefits per trip increased by about $1.60 per added inch in length, holding number the of fish constant. However, the results from Idaho are state averages, and the valuation questions were asked for double the catch and 50 percent larger fish while anglers at Blue Mesa were asked to value a 50 percent increase in catch and a 25 percent increase in size. In a related study, Adamowicz and Phillips (1983) surveyed 272 resident fishermen in Alberta, Canada. The authors reported the marginal value of an additional fish ranged from $1.69 to $2.69 in 1976 Canadian dollars.

Salinity

Two of the project documents reviewed claimed benefits from on-site salt retention. Aside from the technical uncertainty associated with attributing these benefits to the projects, the price used ($56 per ton) grossly over valued these salinity reduction benefits. This price reflects Bureau of Reclamation estimates of value (USBR, 1983) which include secondary or indirect benefits. From a national standpoint, alternative public investments elsewhere would themselves generate secondary impacts. Thus, secondary impacts usually represent no net gain to society and should not be included in a benefit/cost analysis whose accounting stance is national in scope. When USBR value estimates were adjusted for secondary impacts by Gardner and Young (1985), they found that the value of retained salts was approximately $26 per ton. This value is recommended for use in the kinds of analyses reviewed here.

Instream flow

In the arid west, where the law of prior appropriation governs the ownership of water, the "beneficial use" test is taken as a key factor in reviewing requests for the appropriation of water. Historically, beneficial use has been related to the actual physical diversion of water for the production of agricultural commodities, industrial use, or municipal use. These uses were seen as having a tangible economic benefit, which at the time was synonymous with financial return. The value of water in these various uses has been estimated in a number of studies. The best example is the classic study by Young and Gray (1972), updated in Young and Haveman (1985).

Recently, Western states have been forced to give grudging recognition to the concept of instream flow as a beneficial use. A beneficial use is a use which improves the public good (utility). Water flowing in a stream or river is a beneficial use because it meets the two conditions required by economic theory: (1) water in the stream provides enjoyment or increases the utility of recreationists, and (2) instream flows represent a scarce resource.

Loomis (1987) reviews the assumptions, theory, and empirical requirements of the techniques used for the estimation of the economic benefits of instream flows and presents the estimated values of instream flows found in existing but generally unpublished studies. Loomis discusses the use of the Travel Cost Methodology (TCM), the Contingent Value Methodology (CVM) and the Household Production Methodology (HPM). Instream flow studies by Daubert and Young (1981), Walsh et al. (1980), Ward (1985, 1986), Narayanan et al. (1983, 1986), and Amirfathi et al. (1984) are

reviewed. The following table of marginal value per acre foot of water is presented:

Study	State	Method	Marginal value per AC/FT
Ward	NM	TCM	$27.00
Amirfathi	UT	TCM	74.00
Daubert et al.	CO	CVM	15.75*
Walsh et al.	CO	CVM	19.04

*Average of Table 1 values.

Daubert and Young reported that the value of instream uses exceed the marginal value of irrigation during years of normal rainfall. However, when rainfall is less than normal, irrigation values exceed instream uses for recreation activities, and irrigation uses should take precedent.

Loomis concludes that "the tools now exist to determine and defend optimum flows. The time has come for biologists, economists, engineers, and others concerned about the allocation of water in the west to move from concern for minimum instream flows to concern about economically optimum flows."

The most recent work on instream flow is a study of the Grand Canyon by Boyle et al. (1987). Whitewater rafters, fishermen, and day users were surveyed to develop value estimates of different flows. The contingent valuation methodology was used. This study found that passengers on commercial raft trips valued flow at a maximum of $898 for 33,000 cfs. ($12.24 per acre foot). A novel aspect of this study is the extensive research conducted prior to implementing the CVM surveys which was designed to identify important attributes of the recreational experience and to learn about user preferences in qualitative terms.

Wind erosion

Wind erosion costs are incurred both on and off a farm or ranch. Onsite wind erosion reduces production and increases operating costs. Offsite costs are felt by households, private farms, and government agencies in the form of increased cleaning, maintenance and replacement expenditures, and reduced consumption and production opportunities. In a study of wind erosion in New Mexico, Huzar and Piper (1986) estimated offsite costs for the household and business sectors using a mail survey. They derived the impacts on the government sector from data provided by local government agencies. The total offsite cost to households was estimated to be approximately $457.60 million per year and the total cost to businesses approximately $7.57 million

per year. The total cost to all sectors was $466 million or the equivalent of $3 per ton of wind eroded soil. The results indicate that the onsite costs ($10 million) and may, in fact, be comparable in magnitude to those of water erosion.

Water erosion

Moore and McCarl (1987) report one of the few studies of the offsite costs of water erosion. They describe the objective of their research as the execution of "a pilot case study examining a number of offsite items through which soil erosion may impose costs on society, and constructing preliminary estimates on the relative magnitude of these costs." The authors estimated the offsite impacts on the cost of municipal water treatment, the cost of road maintenance, the cost of river channel maintenance, and the cost of operating downstream reservoirs and hydroelectric facilities. The impact of sediment on the cost of water treatment was estimated using a simulation model. The results of this procedure indicated that the cost of water treatment would change only .33% for each 1% change in sediment over a wide range of sedimentation levels. Treatment costs would decline $3,385 for each 1% decline in sediment level.

Average road maintenance costs were also estimated. Using an assumption of constant costs per mile it was found that average road maintenance costs due to sediment removal were $4.22 million. The average annual cost for river dredging, as determined from U.S. Army Corp of Engineers data, was found to be $270,125 or $0.85 per ton of sediment removed. Overall, offsite cost of soil erosion in these three cost categories was estimated to be $5,532,257 annually. Assuming a soil loss rate of 3 tons per acre over the entire 6,350 square mil study area, the average offsite cost of soil erosion is approximately $0.45/ton.

Reduction in channel and reservoir storage capacities may be the most serious and costly impact of excessive sedimentation. The median storage depletion rate for all U.S. reservoirs is 1.5 percent per year (McDowell et al., 1976). The sedimentation rate is generally higher for small reservoirs than for large reservoirs (Beasley, 1972). Many are filling at a rate of 5 percent of their capacity per year, while those with less than 123,000 m^3 are losing a mean of 2.7 percent of their capacity annually. Replacement of sediment filled reservoirs is often much more costly than the original construction because less optimal secondary sites must be used (Walter et al., 1979).

B-III. Conclusion

Planning always has been a part of BLM management activities, but plans generally were narrow in scope, short-ranged and uncoordinated. Plans for one activity (e.g., range management) were prepared with little or no consideration of

other activities (e.g., wildlife, soil erosion, recreation, etc.). The resulting conflicts, overlaps and omissions within the Bureau's own program caused confusion and uncertainty.

There is a strong tendency for resource management agencies to formulate management plans in terms of structural practices (physical terms - for example) miles of fence to be constructed, number of erosion control structures to be built, etc. The reasons for this are many and complex, traceable in large part to the professional background of personnel and internal structure of the agencies. Whatever the causes, however, the listing of proposed activities in terms of physical goals prevents any rational appraisal of the extent to which these activities contribute to the broad management objectives outlined in statutes and administrative directives.

While the need for some effective means for evaluating and ranking alternative management plans or opportunities has long been recognized, there is less agreement as to what this evaluation format should contain or how it should be used. This greatly complicates the task, but if any system is to be useful, it must contain sufficient information for managers to understand the alternatives and make rational decisions.

The economic component of a planning system should be designed to provide information to insure that management decisions reflect the needs of people. It should show the degree to which people in various user groups, communities, industries, regions, and the nation as a whole depend on BLM resources and what changes in dependency are likely to occur in the future. The function of the economic component is to provide a picture of the supply and demand situation for each resource product attributable to BLM lands, now and in the future.

Land management activities effect local, regional, and national economics in two principle ways. First, the management agency must purchase goods and services from the local economy in order to perform the management activities. Second, the flow of outputs resulting from those activities affects market transactions at the local, regional and national levels. An output is defined as a good, service, or on site use produced from cropland, forest and rangeland resources.

Before a detailed listing of project outputs can be attempted, it is necessary to carefully define the impact area. That is, does the project affect only one farm or ranch, several farms or ranches, a county or a state. The selection of impact area boundaries can drastically alter the list of outputs.

Bureau activities result in many different types of economic outputs. This report reviewed some of the major outputs that should be considered. The decision regarding which outputs to

include in the model should take into consideration the problem being analyzed. The unit of measurement of the outputs should be consistent with commonly used measures so the results of the study are comparable with other studies and usable in the planning process at the regional and national levels.

Economic valuation techniques are reviewed and several suggestions are made to more accurately estimate the value of the economic outputs resulting from rangeland improvement projects. Discussion and estimation procedures are then presented concerning the separation and quantification of the on- and off-site impacts.

Appendix B-A

Willow Creek, Lewiston District, Montana

U S. Dept. of the Interior. 1985. Willow Creek Interdisciplinary Watershed Activity Plan Environmental Assessment. Bureau of Land Management, Lewiston, Montana.

Project description

Willow Creek is located in northeastern Montana near Glasgow. It is a tributary of the Milk River which is within the Missouri River basin and it drains approximately 538 square miles. Approximately 87% of this catchment is managed by the Bureau of Land Management; 6% is owned by the State of Montana, and the remainder is privately owned.

The topography of the region ranges from rimrock and weathered outcrops along ridges which have slopes of less than 35%, to flats and clay hardpans with slopes of less than 5%. The soils in this region are shale derived and have high percentages of clay (up to 65%), high sodium content, and low percentages of organic matter. These soils are characterized by low infiltration and permeability rates. Summer thunderstorms in the region are short but intense storm events. Coupled with the lack of ground cover, these conditions lead to high rates of runoff and sediment yield.

Since 1952 the Bureau of Land Management has been heavily involved in this catchment. Ninety-two watershed conservation structures, primarily detention dams, diversion dams, drop structures, retention and water spreader systems have been constructed. The purpose of these structures is to reduce sediment yield and to favorably alter peak flood flows.

Four alternatives are examined in the environmental assessment. These are (1) continued management, (2) abandonment, (3) reconstruction and major enhancement, and (4) prioritized structure/system management. The authors of this document recommend that the project be abandoned on cost grounds.

Economic analysis employed

Direct costs Generalized engineering studies were used to obtain estimates for the construction costs associated with each alternative. A hydrologic model was used to estimate the flood damages associated with each alternative for a 100-year flood event.

Direct benefits The unit day value approach was used to value the big game, small game, and waterfowl hunting days associated with each of the four alternatives. The U.S. Forest Service standardized value was used to approximate the value of

sediment storage under each alternative. No benefits were claimed for salt storage.

Regional impacts Employment estimates under each alternative were described. However, it was stated in the report that no significant regional impacts would result from any of the four alternatives.

Evaluation of the economic analyses

Direct costs No attempt was made to value the lost forage production associated with the recommended alternative. Forage production associated with this alternative is projected to drop by at least 66% on acres where there are water spreaders. This is likely to have significant impacts on both livestock and wildlife in the project area, particularly given the nutritive qualities of the plant materials produced on the sites involved.

Gross revenues were used to estimate flood losses to agricultural land. This procedure is incorrect unless the relevant costs are subtracted out or included in the "costs" category. Net revenues are the appropriate measure of value lost to society.

Direct benefits Given the methodology which was employed in this study (use of standardized values) the omission of several benefit measures is particularly apparent. Listed in the same table (F-7) with values for hunting and sediment control are standardized values for: nongame use, other recreation use, grazing capacity, improved water quality, and maintained water quality. It would appear that some effort should have been made to estimate these values.

Regional impacts It is asserted in the study that there are no significant regional impacts caused by any of the four alternatives examined. However, this was not borne out by the projected changes in employment which were reported in Table 2.3. Given that a regional impact model is referenced in this report, it would appear that some attempt at multiplier analysis should have been included.

Suggested alternatives for analysis

General It is particularly apparent that all of the alternatives examined were "construction oriented". Other alternatives, for instance improved grazing management, were not examined. Further, the argument advanced under point No. 2, page 16 of the report, appears to violate the axiom of "sunk costs" and seems in part to be an attempt to justify continued BLM operations in the region even though the "abandonment" alternative is recommended.

Direct costs

A methodology is needed to value lost wildlife, fish, recreation user days.

A methodology is needed to value loss or gain of forage and stock watering facilities.

Direct benefits

A methodology is needed to estimate sediment impacts on downstream users.

A methodology is needed to link sediment control to forage productivity.

Appendix B-B

Pinyon Watershed, Cedar District, Utah

Tucker, Ronald. 1985. Bureau of Land Management, U.S. Dept. of the Interior, Report No. EA UT-040-85-87. Cedar City, Utah.

Project description

Pinyon Watershed is an area of approximately 1.5 million acres located to the west of Cedar City, Utah. The climate in the region is arid to semi-arid with mean annual precipitation ranging from 10-16". The topography is typical of the region and is characterized by mixed series of mountain ranges separated by broad fairly flat alluvial valleys. Approximately 90% of the land in this region is federally owned. The chief use of the region is for livestock grazing and secondarily, for mining.

Extensive grazing has, over time, contributed to the degradation of riparian and water-table associated habitat. Projects are proposed for the improvement and reclamation of these areas. Two alternatives are examined in the Environmental Assessment. These are: (1) do nothing alternative and (2) construction of various improvement devices such as check dams and gabions and the construction of fences to exclude livestock from streambanks and springs. The authors of the report recommend alternative number two.

Economic analyses employed

Direct costs Estimates of the construction costs at each site were developed based on standard engineering practice.

Direct benefits Three types of project benefits were valued. These were: retention of soil on site, the value of maintaining existing water sources, and the value of protecting county roadways from erosion damage. The following methodology was applied.

Soil It was assumed that if soil were to continue to be lost from the site, the site productivity would decline the equivalent of one ecological site class within 20 years. The number of AUM's which would be lost on a particular site classification was then used as an estimate of the avoided cost or benefit of project construction.

Water source It was assumed that without the construction of the project the water sources would become unavailable or unusable. The time frame of occurrence was unspecified. The area around the water

source would then be unusable for livestock. The number of AUM's lost in the effected area was then calculated. The project benefit was then said to be the avoided cost of this loss.

Roadway protection It was assumed that structures protecting county roads from erosion damage would save $400.00 annually in road construction and maintenance costs. These benefits were assumed in year one, in most cases, and in year 10 in other cases.

Regional impacts There was no discussion of employment effects nor regional impacts in this analysis.

Evaluation of the economic analyses

Direct costs Estimated construction costs appear to be uniformly low. In fact it is difficult, in the case of certain sites, to imagine that labor costs will be covered. In addition, there is no mention of the preliminary hydrologic studies which would be necessary to determine the design specifications of some of the structures involved.

Direct benefits It is impossible to ascertain from the text the precise methodology used to estimate project benefits in the case of soil retention. This is particularly true in light of the fact that Table A1.1 is omitted from the report. Furthermore, there is no mention of the value used, per AUM, in this study.

There is no attempt made in this study to measure the benefits (or costs) of the impacts to wildlife and recreation in the project area. In that the area impacted is critical wildlife habitat, in this arid region, this would appear to be a serious omission.

Regional impacts Some discussion of employment impacts, and impacts on the incomes of grazing lease holders is necessary.

Suggested alternatives for analyses

General It is clear that there were really no alternatives examined in this analysis. The only choice offered was "with project" or "without project". There are several obvious alternatives which were not examined: (1) Improved Grazing Management, (2) Cessation of livestock use for a specified period, and (3) Selective use of structures and for (1) and for (2) above.

Direct costs

Considerably more attention must be given to the engineering cost estimates and procedures for deriving these.

A methodology is needed to value lost wildlife and recreation user days.

A methodology is needed to value loss or gain of forage and stock watering facilities.

Direct benefits

Methodology is needed to estimate sediment impacts on downstream users.

Methodology needed to link sediment control to production of forage.

Regional impacts

Methodology needed to link AUM loss or gain to regional incomes, etc.

Appendix B-C

Bear Creek, Prineville District, Oregon

Century Testing Laboratories, Inc. 1980. The Bear Creek Watershed Project. Report to the Bureau of Land Management, U.S. Dept. of the Interior, Bend, Oregon.

Project description

The Bear Creek Watershed is located approximately 22 miles south of Prineville, Oregon. Approximately 55,500 acres are included in the watershed of which 41,600 acres are controlled by the BLM. The majority of the area is capped by ancient basaltic flows. Edges of the flows form near vertical faces in the upper canyons. Soils are primarily volcanically derived and are high in silt and pumice content. Short intense thunderstorms are common but not frequent in the watershed. Ground cover is sparse due to the invasion of the region by western juniper and due to intense grazing pressure. Given these conditions, the erosion rate in the watershed is quite serious. Sheet, rill and gully erosion are all in evidence. Also of major concern is the stability of the banks of streams in the region.

In 1973, the Prineville District BLM implemented a watershed improvement plan in the Bear Creek Watershed. The primary purpose of this program is to reduce soil loss, reduce sedimentation and improve forage production. A variety of improvement techniques were implemented. The most important of these were the removal of western juniper, development of springs for use by livestock, fencing riparian zones, and the construction of sediment traps.

Economic analyses employed

No economic analyses of any kind are included in this report.

Appendix B-D

Lower Wolf Creek, Craig District, Colorado

U.S. Dept. of the Interior. 1985. Lower Wolf Creek Environmental Assessment. Bureau of Land Management, Craig, Colorado.

Project description

The White River resource area is located southwest of Elk Springs, Colorado. The project site is characterized by numerous discontinuous gullies on the uplands which are continually migrating upstream. Sage brush is the dominant woody vegetation in the area. Annual precipitation in the area is approximately 10 inches. About two-thirds of this precipitation occurs in the summer months in the form of showers and intense thunderstorms. Soils in this region are generally silty clays underlain by clay subsoil and Mancos shales. They are characterized by a high salt content. Soil erosion estimates from the project sites are between 5 to 12 tons/acre/year. Associated salt yields range from .17 to .40 tons/acre/year.

The BLM proposes to construct a number of gully plugs, drop structures, and sediment pits to reduce the present rate of soil erosion, control salinity, and improve forage production. Two alternatives are presented: (1) the no action alternative and (2) the construction alternative. Adoption of alternative (2) the construction alternative is recommended.

Economic analyses employed

Direct costs Generalized engineering studies were used to obtain estimates of the construction cost at each site. Structure design was based on a "25-year 6-hour event", however the methodology employed is not described.

Direct benefits The following project benefits were estimated: salinity reduction, sediment reduction, increased livestock use, and "increased wildlife use". The methodologies which follow were employed.

Salinity The amount of salt stored by each structure was estimated as 3% of the sediment stored by the structure. The value of a ton of salt stored was $56.60 as described in USBOR Progress Report 11, Jan. 1985. The full citation for this report is not attached.

Sediment The tons of sediment stored by each structure is a function of its storage volume times 115 lbs/ft^3 converted to tons. Each ton of sediment

was valued at $6.00 as described by the National Soils Handbook. The full citation for the handbook is not attached.

Livestock Each AUM was valued at $9.04.

Wildlife The methodology used to value increased wildlife use of the project area is unclear. See the discussion of the economic analyses section which follows.

Regional impacts There is no discussion of regional impacts.

Evaluation of the economic analysis

General comments There is some discrepancy in the benefits lifespan. In all projects, other than drop structures, a discounted benefits stream is reported for 25 years, far beyond the expected lifespan of the associated project.

There appears to be an error in the "near 964" column of Table 2. The entry "Salinity Reduction Salts Stored" was apparently not discounted. Benefits are therefore overstated. This will change the outcome of the analysis in this case.

Direct costs Estimates of cost appear to be based on reasonable assumptions. However, there appears to be some discrepancy in the way in which these costs were incorporated into the benefit cost analysis. The expected lifespan of each type of structure is clearly stated: drop structures, 25 years; pits, 10 years; and gully plugs, 5 years. However, while the benefits for each of these structures are apparently extended over all 25 years in the B/C analysis, no allowance for the reconstruction of the projects at the end of their useful lifespan is made. Thus, benefits accrue long after the structure is no longer functional. This procedure is clearly incorrect.

Direct benefits

Salinity Salinity control is a major component of the benefits estimated for each structure. In a number of instances the value ascribed to salt storage "carries" the project. However, there is a reasonable doubt that the salinity reduction benefits claimed for these structures will be realized. There are two reasons for this. First, design specification do not call for an impermeable layer to be incorporated into the proposed structures. As most of the structures are located on alluvial deposits and/or highly erodible soils, there is no barrier to prevent rapid migration of trapped salts into the ground water. Further, the design of the proposed structures is such that the rated storage capacity will frequently be exceeded,

particularly during the latter stages of the project lifespan. It is likely then, that water passing over the structure will remove some, or all, of the previously precipitated salts.

Increased wildlife use Item "f" on page 28 states that "Mule deer habitat would not expectantly be altered in one way or another as a result of the project implementation." This statement is not consistent with the addition of $1,225.00 in benefits to seven out of eight construction projects. Further, it remains unclear how this value was derived. Footnote 6 on Table 2, indicates that $1,225.00 is the assumed annual value of 1 deer, while this value is treated as the Present Value of Benefits in the table. By comparison, the present value of benefits resulting from increased livestock use is no higher than $226.00 for any of the projects.

Suggested alternatives for analysis

General comments It is clear that there were really no alternatives examined in this analysis. The only choice offered was "with project" and "without project". There are several obvious alternatives which should have been examined. These are (1) improved grazing management, (2) cessation of livestock use, either entirely, or for a specified period, and (3) selective use of structures and some combination of (1) and/or (2) above.

Direct costs

Considerably more attention should be paid to the technical aspects and feasibility of these projects, particularly as they pertain to salt storage. It is likely that the stated design specifications are sufficient to retain only a portion of the salt claimed.

Attention should be paid to the likelihood of livestock loss due to miring and drowning in the proposed structures. This is alluded to in the report. Fencing or livestock removal, if necessary, are measures which would add tremendously to the costs of the proposed projects.

Direct benefits

No attempt was made to estimate the effects of improved water quality even though this is mentioned on page 26. This should be included in the analysis.

No attempt was made to estimate the benefits of the reduced rate of sedimentation on downstream reservoirs even though this is mentioned on page 29. This should be included in the analysis.

Regional impacts

Given that the total cost of the project is less than $40,000 it seems unlikely that a regional impact assessment is warranted.

Appendix B-E

Elephant Skin Wash, Montrose District, Colorado

U.S. Dept. of the Interior. 1984. Elephant Skin Wash Salinity Control Project. Bureau of Land Management, Montrose, Colo.

Project description

Elephant Skin Wash, formerly referred to as Watershed IB, is a 3.70 square mile watershed located 5 miles northeast of Montrose, Colorado in the Uncompahgre River Drainage, which is part of the Colorado River Basin. The climate is semi-arid with annual precipitation ranging from 9 to 12 inches and annual temperature of 49 degrees F.

The geology of the area is dominated by Mancos shale. Mancos shale is a marine derived shale which has a high concentration of salts. On steeper slopes the shale is either just a few inches below the surface or is exposed. The terrain consists of rolling to very steep, nearly barren slopes on southern exposures within a fairly steep-walled box canyon.

The soils of the basin are largely undeveloped on the shale uplands. Billings silty clay loam has formed in the alluvium of the drainage floodplains. This deep, well drained soil has moderate limitations for building dikes due to piping and low strength when wet. Erosion is 4-6 tons per acre per year because of the nature of the soils and the sparseness of vegetation cover. Mass erosion and rilling are the major erosion processes on shale badlands. Gully, rill, and interrill are the predominant erosion processes on the alluvial bottomland.

The following alternatives were examined (1) ponding dike project, (2) retention pond project, and (3) no action. BLM has chosen the ponding dike alternative as the proposed action to be taken, because of the long-term benefits to become of it, i.e., reduction in salt content flowing into lower basin.

Economic analyses employed

Direct costs A general engineering study was apparently used to obtain construction cost estimates. A hydrologic model was used to estimate runoff and peak flow. These parameters were then incorporated into the design of the proposed structures. Subsequently, a detailed on-site estimate of costs was prepared. The total cost of construction was revised upward from $29,747 to $58,083.

Direct benefits Two direct benefits were estimated for this project. These were the value of the sediment and the salt

retained on-site. It was assumed that the project would capture 1/2 of the estimated sediment yield from this watershed, or 1746 tons of sediment. The value of the trapped sediment was assumed to be $1.00/ton. Salt trapped on-site was projected to be 29.368 tons per year. The avoided cost of salinity was assumed to be $56.66/ton based on a Water and Power Resources Service 1980 Report.

Regional impacts No regional impact assessment of any kind was included in this report.

Evaluation of the economic analysis

General There are a number of flaws apparent in the methodology used in the Benefit/Cost analyses presented in this report. First, although two alternatives are presented in the text, only one alternative, the recommended alternative, is examined in terms of benefits and costs. This robs the decision maker of any discretion in-so-far as alternatives are concerned. Worse, the entire "benefit cost analysis" presented in the June 1984 Addendum is apparently erroneous. The values for the uniform series equivalent annual cost of the project ($3,057) and the total benefits from salt reduction ($31,616) are incorrect due to errors in applying accepted discounting procedures. Further, the benefit/cost ratio is incorrectly defined. Using the assumptions and values listed on page 2 of the addendum, it can easily be shown that this project has a benefit cost ratio of 0.57 rather 1.12 as stated in the report.

Direct costs It is apparent from the attached addendum that construction costs were grossly underestimated initially. Even after these costs were revised, the footnote on page 2 of the addendum states that "maintenance costs are not included" as costs in the benefit/cost analysis. This procedure is clearly in violation of accepted practice. Estimated costs rose from $29,747 to $58,083. Given this disparity in estimates, it would seem probable that further variations in actual construction costs might be expected. A sensitivity analysis is recommended.

Direct benefits Salinity control is the primary component of this project. However, there is at least a reasonable doubt that the salinity reduction benefits claimed for the proposed structures will be realized. There are two reasons for this. First, an impermeable layer is not specified in the design specifications. Infiltration of water through, around, or under these structures as mentioned on page 8 is likely to remove the salt from the structure. Second, the design of the structure is such that particularly in the latter years of the project overtopping is expected. This appears likely to re-dissolve and remove much of the previously trapped salt. The comments attached at the back of this report (Appendix II) are highly critical of the benefits claimed by this project. The concerns

voiced are addressed in only a very cursory manner. Given the doubts that exist, further technical work on this issue appears warranted before this project is undertaken for the reasons stated.

Regional impacts No Regional assessment was included in this report.

Suggested alternatives for analysis

General It is clear that all of the alternatives examined are construction alternatives in some form or another. Given that the objective is to reduce sedimentation and hence salinity, there may be other methodologies available besides construction of containment structures. Other alternatives may be feasible such as revegetation of the watershed and/or improved grazing management. These alternatives should be examined.

Direct costs

Considerably more attention must be paid to estimating the construction and maintenance costs. Ancillary costs such as fencing and "weep pipes" (see page 14) should be included in the cost estimates. Estimation methods and assumptions should be clearly stated for each structure.

Direct benefits

Further refinement is necessary in estimates of saliny benefits.

Methodology is needed to estimate impacts on wildlife and livestock populations in the project area.

Regional impacts It is likely that no regional impact assessment is necessary for this scope of project.

Appendix B-F

Long Gulch, Montrose District, Colorado

U. S. Dept. of the Interior. 1985. Long Gulch Sediment Control and Riparian Habitat Improvement Plan. Bureau of Land Management. Gunnison, Colo.

Project description

Long Gulch is a watershed located approximately six miles southeast of Gunnison, Colorado. The watershed covers approximately 25 square miles and ranges in elevation from 7800' to 9600'. The climate in the region is semi-arid with mean annual precipitation ranging from 12 to 16 inches. Most of the precipitation occurs in July and August in the form of violent thunderstorms. Soils on the project site are deep and alluvially derived. Long Gulch itself is an intermittent stream that flows largely in response to snowmelt and rainfall events. The project area, in general, has been impacted by overgrazing. In addition, a prescribed burn initiated by the BLM triggered rapid and severe erosion in two tributary watersheds. The BLM proposes to construct a series of gabions, gully plugs, check dams, and to use other means such as fencing and re-seeding in order to reduce sediment loss on this watershed. Three alternatives are mentioned. These are: (1) check dams and headcut treatment, (2) headcut treatment alone, and (3) the no action alternative. Only one of the proposed alternatives, alternative (1), check dams and headcut treatment, was actually examined. Alternative (1) was recommended.

Economic analysis employed

Direct costs The cost of constructing alternative (1) is stated to be $15,000. The costs of the other alternatives are not presented.

Direct benefits The benefits from increased forage production and on-site sediment retention were estimated for this analysis. The value of an additional A.U.M. of grazing was assumed to be $8.00. The value of each ton of sediment retained on-site was assumed to be $6.00 per ton. No other project benefits were estimated.

Regional impacts No discussion of regional impact was contained in this report.

Evaluation of the economic analysis

General It appears the basic tenants of benefit/cost analyses were violated repeatedly in this report. First, although three alternatives are presented in the text, benefits

and costs are presented for only one of these. Thus, the decision maker has no decision options. Secondly, the logic used in aggregating the various construction tasks together into alternative (1) appears, at least superficially, to be flawed. It would appear that the inclusion of that portion of the costs necessary to repair the damage from the controlled burn may be incorrect. Seemingly these costs should have been allocated to the ex-post costs or dis-benefits of the controlled burn. Finally, the statement on page 17 that "the proposed project would be economically feasible since it would reduce loss of productive soil and degradation of water quality on public lands" remains unsupported by the calculated benefit/cost ratio for alternative (1) of .52.

In addition, the statement on page 16 that "Water for livestock use would be piped from the stock pond to a trough placed out of the riparian zone using wildlife funding" indicates that some of the direct costs attributable to this project have been excluded from the analysis. This is clearly incorrect.

Direct costs It is not stated anywhere in the report how the project costs were estimated. Further, it is unclear whether the various ancillary costs such as fencing and monitoring, which are mentioned in the report, are included in the estimated project costs. A highly simplistic hydrologic risk analysis is presented. However, no reference for the methodology used is provided. It is unclear, therefore, whether the cost estimates provided in the report have been adjusted to account for the probability of structural failure during the design life of the project.

Direct benefits The methodologies which were used to estimate the physical benefits such as sediment retention and increased forage production are not contained in this report. Hence, it is unclear how these outputs were estimated. However, it would appear that grazing benefits are substantially overestimated since the figures presented appear to assume 100% utilization of the increased forage over the entire 12-month period. This is inconsistent with an earlier statement that the area is used only for summer grazing.

A number of additional project benefits are mentioned in the report such as: improved water quality, restoration of riparian habitat, decreased peak flows, and increased wildlife populations. None of these benefits are valued. It would appear that some estimates of these benefits, in physical units, could have been made at low cost. The unit value approach could then have been used to estimate the value of these outputs in the same manner as sediment retention was valued.

Regional impacts No regional impact assessment was included in this report.

Suggested alternatives for analysis

General - It is apparent from the scope of the alternatives presented that they are all construction alternatives of one form or another. It seems obvious that additional alternatives such as reduced grazing and/or improved grazing management schemes should have been considered either independently or in combination with the construction alternatives presented.

Direct costs

Considerably more attention must be given to the engineering cost estimates and the procedures for deriving these. The methodologies and assumptions used should be clearly stated. All direct costs resulting from the project should be identified and valued.

Methodology is needed to value the loss (or gain) of stock watering facilities

Direct benefits

Methodology is needed to estimate sediment impacts on downstream users if any.

Methodology is needed to clearly link sediment and erosion control measures to forage production.

Gains in wildlife use and associated recreation must be estimated and valued.

Regional impacts

Depending on the size of this project in relation to the size of the regional economy, a regional impact assessment may or may not be warranted.

Appendix B-G: Sageram

Shortly after the last of the six watershed studies were completed in September, 1985, the Bureau of Land Management adopted for resource investment analyses a program named "Sageram". This program provides a basis for integrating efficiency considerations into design of resource investment proposals in order to maximize the economic return per dollar invested. "Sageram provides a consistent means of measuring relative economic efficiency of investment proposals among allotments (or other entities) within an administrative unit(Resource Area, District, or State) and provides information needed to rank range improvement/investment proposals within a planning area. The system can be used to reformulate investment plans to provide more benefits within a fixed budget, or to achieve specific objectives with less cost" (U.S. Dept. of the Interior, 1985).

This provides a readily available technique for economic analysis of on-site benefits and costs resulting from project proposals. Benefits are typically measured as the difference between the resource outputs (in dollars) expected over a 50-year period with the project versus resource outputs expected without the project. Costs include new project costs, operation and maintenance costs, and replacement costs. Included in operation costs are annual costs to BLM and others that are incurred as a result of using or managing the new structures or systems.

The model uses several different discount rates in the analysis. Benefit-cost ratios as well as internal rates of return are calculated on a present value basis. However, only on-site, market priced outputs are included in the analysis provided by Sageram. Non-market outputs such as aesthetics need to be handled outside the model. An evaluation system of these non-market outputs is discussed in Handbook, H-1740-1.

Livestock forage outputs are treated slightly differently in the Sageram program. The reason for this difference is due to the manner in which livestock forage attains economic significance for BLM. Since livestock forage production is distributed to users on an allocation basis, and allocation changes are only made once every 3 to 5 years, therefore the economic impact of forage production does not change on an annual basis. Changes in livestock forage are treated in the model in a stepwise manner reflecting the 3- to 5-year delay in allotment changes. A complete discussion of how livestock forage is handled in Sageram is presented in Chapter 5 of Handbook H-1743-1.

In addition to livestock forage, the following on-site outputs are provided for in the Sageram analysis: elk hunting, deer hunting, antelope hunting, other big game hunting, waterfowl

hunting, upland small game hunting, warm-water angling, cold-water angling, developed site recreation, dispersed recreation, nongame wildlife, and soil water damage avoided. There is also space for specification of three additional output benefit categories.

Sageram is an on-line workable economic evaluation model specifically developed to handle small area analysis for the Bureau of Land Management. In almost all cases it will provide meaningful economic estimates of resource investment activity. The model is critically dependent on the reliability of the input data. If the input data is flawed this will be magnified in the results. Of major concern is the projection of outputs into the future with and without resource improvements. Since these projections need to be performed for each output it is imperative that careful consideration be made. Possible errors in output estimates need to be carefully monitored. Errors in improvement costs and output pieces are less likely to occur because standard prices and cost estimates are available at the district or state level.

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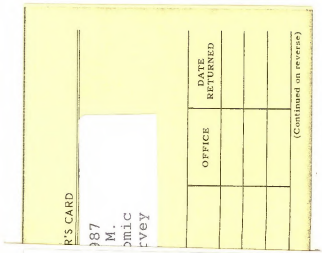

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